

# Python Imaging Library

Tushar B. Kute,  
<http://tusharkute.com>



# Python Imaging Library

- The Python Pillow library is a fork of an older library called PIL.
- PIL stands for Python Imaging Library, and it's the original library that enabled Python to deal with images.
- PIL was discontinued in 2011 and only supports Python 2. To use its developers' own description, Pillow is the friendly PIL fork that kept the library alive and includes support for Python 3.

# Python Imaging Library

- There's more than one module in Python to deal with images and perform image processing.
- If you want to deal with images directly by manipulating their pixels, then you can use NumPy and SciPy.
- Other popular libraries for image processing are OpenCV, scikit-image, and Mahotas. Some of these libraries are faster and more powerful than Pillow.

# Python Imaging Library

- Pillow remains an important tool for dealing with images. It provides image processing features that are similar to ones found in image processing software such as Photoshop.
- Pillow is often the preferred option for high-level image processing tasks that don't require more advanced image processing expertise. It's also often used for exploratory work when dealing with images.
- Pillow also has the advantage of being widely used by the Python community, and it doesn't have the same steep learning curve as some of the other image processing libraries.

# Image Module and Image Class

- The main class defined in Pillow is the Image class. When you read an image using Pillow, the image is stored in an object of type Image.
- You call the `open()` function to read the image from the file and `.load()` to read the image into memory so that the file can now be closed.
- You use a with statement to create a context manager to ensure the file is closed as soon as it's no longer needed.

# Basic Image Manipulation

- You can manipulate the image beyond cropping and resizing. Another common requirement is to rotate or flip the image.
- You can use the `.transpose()` method for some transformations.

# Basic Image Manipulation

- There are seven options that you can pass as arguments to `.transpose()`:
  - `Image.FLIP_LEFT_RIGHT`: Flips the image left to right, resulting in a mirror image
  - `Image.FLIP_TOP_BOTTOM`: Flips the image top to bottom
  - `Image.ROTATE_90`: Rotates the image by 90 degrees counterclockwise
  - `Image.ROTATE_180`: Rotates the image by 180 degrees

# Basic Image Manipulation

- `Image.ROTATE_270`: Rotates the image by 270 degrees counterclockwise, which is the same as 90 degrees clockwise
- `Image.TRANSPOSE`: Transposes the rows and columns using the top-left pixel as the origin, with the top-left pixel being the same in the transposed image as in the original image
- `Image.TRANSVERSE`: Transposes the rows and columns using the bottom-left pixel as the origin, with the bottom-left pixel being the one that remains fixed between the original and modified versions



# Resolution

- Every pixel in an image can only take on a single value. In other words, it's not possible to have more than one detail within a pixel. So, the higher the number of pixels, the greater the potential for more detail in the image.
- 'Potential' is the operative word here; the level of detail in images depends on more than simply the number of pixels present.
- Image noise, lens quality and photographic technique all have a significant hand in how detailed an image ends up, as does the specific processing applied to the image upon its capture, and the strength – or absence – of anti-aliasing filters in front of the sensor.
- A higher resolution image may give you a bigger image to view, but this doesn't necessarily mean it will display more detail.

# Sharpness vs. Resolution

- Sharpness concerns how clearly defined details within images appear, and is, strictly speaking, subjective (whereas the number of pixels in an image can be easily quantified).
- It's entirely possible to have an image that's high in resolution that doesn't quite look sharp, just as it's possible to have a low-resolution image that appears nice and crisp.
- Much depends on how the image is being viewed, from what distance, and exactly who is viewing it.

# Low Resolution Image

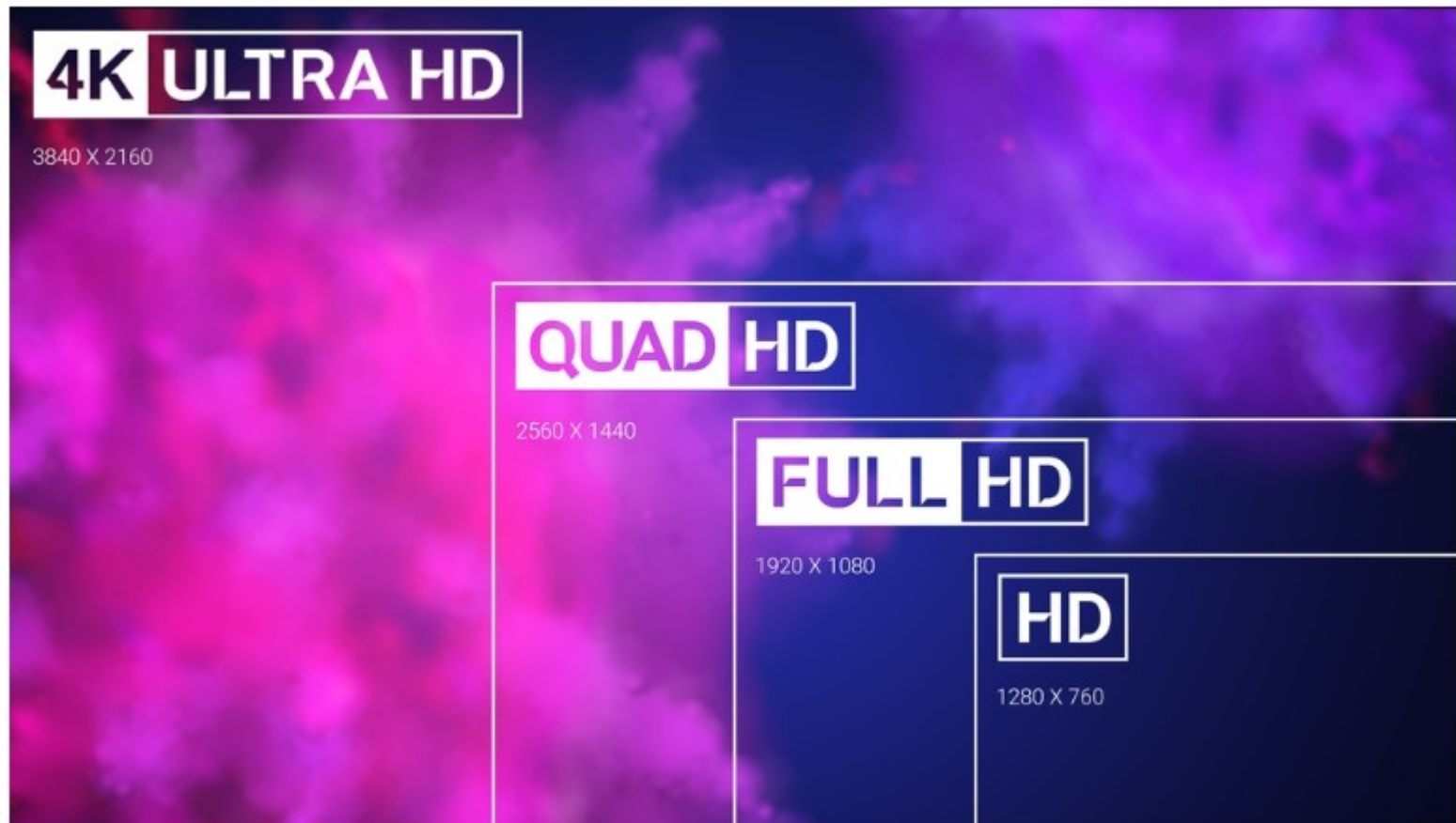
- There is no specific cut-off point for a low-resolution image as it really depends on how and where it is being used.
- But an image with a three-figure pixel count in both dimensions would rarely be considered high-resolution for most uses.
- Even an image that measures 1920 x 1080 pixels, for example, would only equate to around 2MP.
- This is usually fine for online use but far smaller than what today's cameras and phones produce as standard.

# PPI and DPI

- These two acronyms are often used interchangeably although they do have different meanings.
  - PPI (Pixels Per Inch) refers display resolution, or, how many individual pixels are displayed in one inch of a digital image.
  - DPI (Dots Per Inch) refers to printer resolution, or, the number of dots of ink on a printed image.

- 4K is a term that's been used widely in recent years, be it on new televisions and computer displays through to the likes of Netflix and other content providers.
- Typically, the term is used to describe either a video or piece of content that can be recorded, played or streamed at around 4000 pixels in width, or a device that's capable of displaying it at this level.

# 4K



# Image Quality

- In addition to image size, the quality of the image can also be manipulated. Here we use the word "compression."
- An uncompressed image is saved in a file format that doesn't compress the pixels in the image at all.
- Formats such as BMP or TIF files do not compress the image.
- If you want to reduce the "file size" (number of megabytes required to save the image), you can choose to store your image as a JPG file and choose the amount of compression you want before saving the image.

# Resolutions

Megapixels	Image Resolution	Maximum Print Size
0.3 Megapixel	640 x 480	1.6" x 2.3" at 300 dpi
1.3 Megapixel	1392 x 1024	3.2" x 4.3" at 300 dpi
2.0 Megapixel	1600 x 1200	4" x 5.3" at 300 dpi
3.3 Megapixel	2080 x 1542	5.1" x 6.8" at 300 dpi
5.0 Megapixel	2580 x 1944	6.4" x 8.5" at 300 dpi
6.0 Megapixel	2816 x 2112	9.4" x 7" at 300 dpi
8.0 Megapixel	3264 x 2448	8" x 11" at 300 dpi
12.5 Megapixel	4080 x 3072	10.24" x 13.6" at 300 dpi
32 Megapixel	6464 x 4864	16" x 21.5" at 300 dpi



# Bitmap

- A bitmap is a mapping from some domain (for example, a range of integers) to bits. It is also called a bit array or bitmap index.
- As a noun, the term "bitmap" is very often used to refer to a particular bitmapping application: the pix-map, which refers to a map of pixels, where each one may store more than two colors, thus using more than one bit per pixel.
- In such a case, the domain in question is the array of pixels which constitute a digital graphic output device (a screen or monitor).
- In some contexts, the term bitmap implies one bit per pixel, while pixmap is used for images with multiple bits per pixel

# Bitmap

- A bitmap is a type of memory organization or image file format used to store digital images.
- The term bitmap comes from the computer programming terminology, meaning just a map of bits, a spatially mapped array of bits.
- Now, along with pixmap, it commonly refers to the similar concept of a spatially mapped array of pixels.
- Raster images in general may be referred to as bitmaps or pixmaps, whether synthetic or photographic, in files or memory.

# Bitmap

- Many graphical user interfaces use bitmaps in their built-in graphics subsystems; for example, the Microsoft Windows and OS/2 platforms' GDI subsystem, where the specific format used is the Windows and OS/2 bitmap file format, usually named with the file extension of .BMP (or .DIB for device-independent bitmap).
- Besides BMP, other file formats that store literal bitmaps include InterLeaved Bitmap (ILBM), Portable Bitmap (PBM), X Bitmap (XBM), and Wireless Application Protocol Bitmap (WBMP).
- Similarly, most other image file formats, such as JPEG, TIFF, PNG, and GIF, also store bitmap images (as opposed to vector graphics), but they are not usually referred to as bitmaps, since they use compressed formats internally.

# Raster Image Files

- Raster images are constructed by a series of pixels, or individual blocks, to form an image.
- JPEG, GIF, and PNG are all raster image extensions. Every photo you find online or in print is a raster image.
- Pixels have a defined proportion based on their resolution (high or low), and when the pixels are stretched to fill space they were not originally intended to fit, they become distorted, resulting in blurry or unclear images.

# Vector Image Files

- Vector images are far more flexible. They are constructed using proportional formulas rather than pixels.
- EPS, AI and PDF are perfect for creating graphics that require frequent resizing. Your logo and brand graphics should have been created as a vector, and you should always have a master file on hand.
- The real beauty of vectors lies in their ability to be sized as small as a postage stamp, or large enough to fit on an 18-wheeler!

# JPEG (or JPG) - Joint Photographic Experts Group



- JPEGs might be the most common file type you run across on the web, and more than likely the kind of image that is in your company's MS Word version of its letterhead.
- JPEGs are known for their "lossy" compression, meaning that the quality of the image decreases as the file size decreases.

# JPEG (or JPG) - Joint Photographic Experts Group



- You can use JPEGs for projects on the web, in Microsoft Office documents, or for projects that require printing at a high resolution.
- Paying attention to the resolution and file size with JPEGs is essential in order to produce a nice-looking project.

# JPG vs. JPEG

- There is no difference between the .jpg and .jpeg filename extensions. Regardless of how you name your file, it is still the same format and will behave the same way.
- The only reason that the two extensions exist for the same format is because .jpeg was shortened to .jpg to accommodate the three-character limit in early versions of Windows.
- While there is no such requirement today, .jpg remains the standard and default on many image software programs.



# PNG - Portable Network Graphics

- PNGs are amazing for interactive documents such as web pages but are not suitable for print.
- While PNGs are "lossless," meaning you can edit them and not lose quality, they are still low resolution.
- The reason PNGs are used in most web projects is that you can save your image with more colors on a transparent background. This makes for a much sharper, web-quality image.

# GIF - Graphics Interchange Format

- GIFs are most common in their animated form, which are all the rage on Tumblr pages and in banner ads.
- It seems like every day we see pop culture GIF references from Giphy in the comments of social media posts. In their more basic form, GIFs are formed from up to 256 colors in the RGB colorspace.
- Due to the limited number of colors, the file size is drastically reduced.
- This is a common file type for web projects where an image needs to load very quickly, as opposed to one that needs to retain a higher level of quality.

# TIFF - Tagged Image File

- A TIF is a large raster file that doesn't lose quality. This file type is known for using "lossless compression," meaning the original image data is maintained regardless of how often you might copy, re-save, or compress the original file.
- Despite TIFF images' ability to recover their quality after manipulation, you should avoid using this file type on the web.
- Since it can take forever to load, it'll severely impact website performance.
- TIFF files are also commonly used when saving photographs for print.

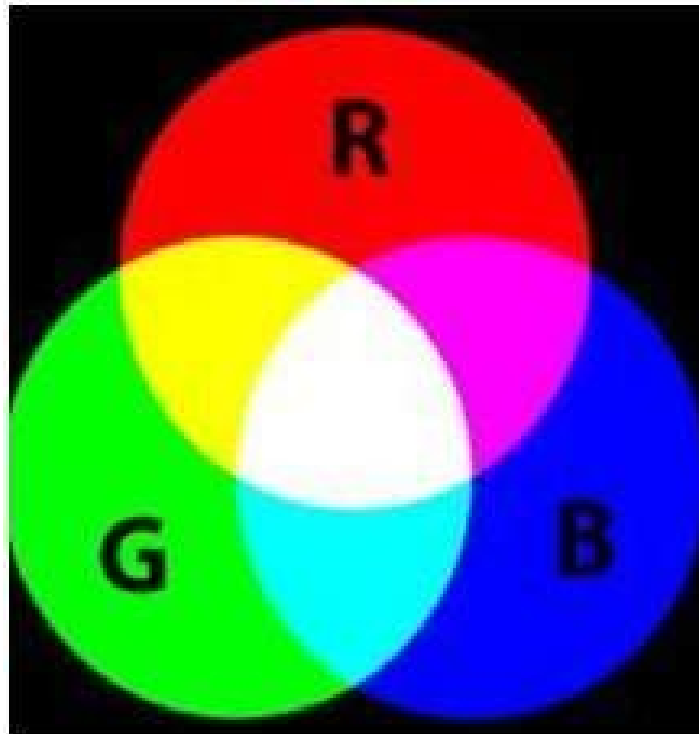
# Color Space

- Color spaces are different types of color modes, used in image processing and signals and system for various purposes. Some of the common color spaces are:
  - RGB
  - CMY'K
  - Y'UV
  - YIQ
  - Y'CbCr
  - HSV

# RGB

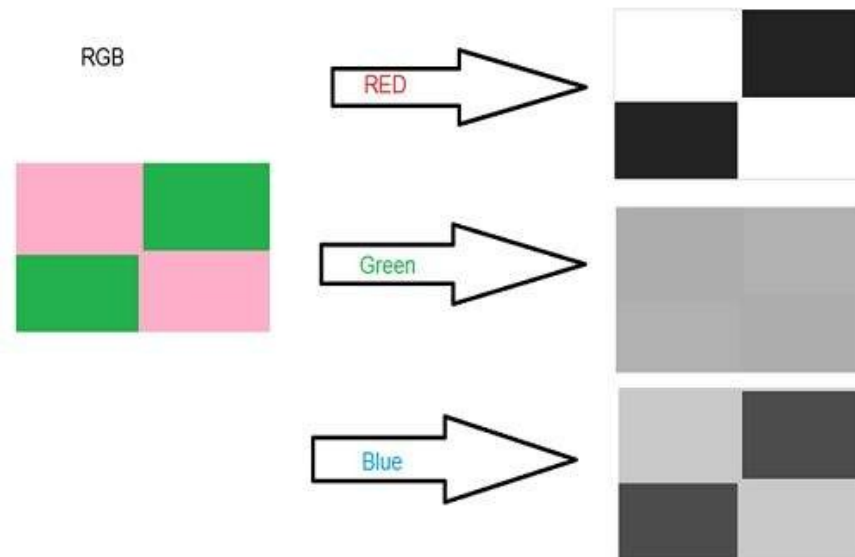
- RGB is the most widely used color space, and we have already discussed it in the past tutorials. RGB stands for red green and blue.
- What RGB model states, that each color image is actually formed of three different images. Red image, Blue image, and black image.
- A normal grayscale image can be defined by only one matrix, but a color image is actually composed of three different matrices.

# RGB



# RGB

- One color image matrix = red matrix + blue matrix + green matrix
- This can be best seen in this example below.



# RGB Applications

- The common applications of RGB model are
  - Cathode ray tube (CRT)
  - Liquid crystal display (LCD)
  - Plasma Display or LED display such as a television
  - A compute monitor or a large scale screen



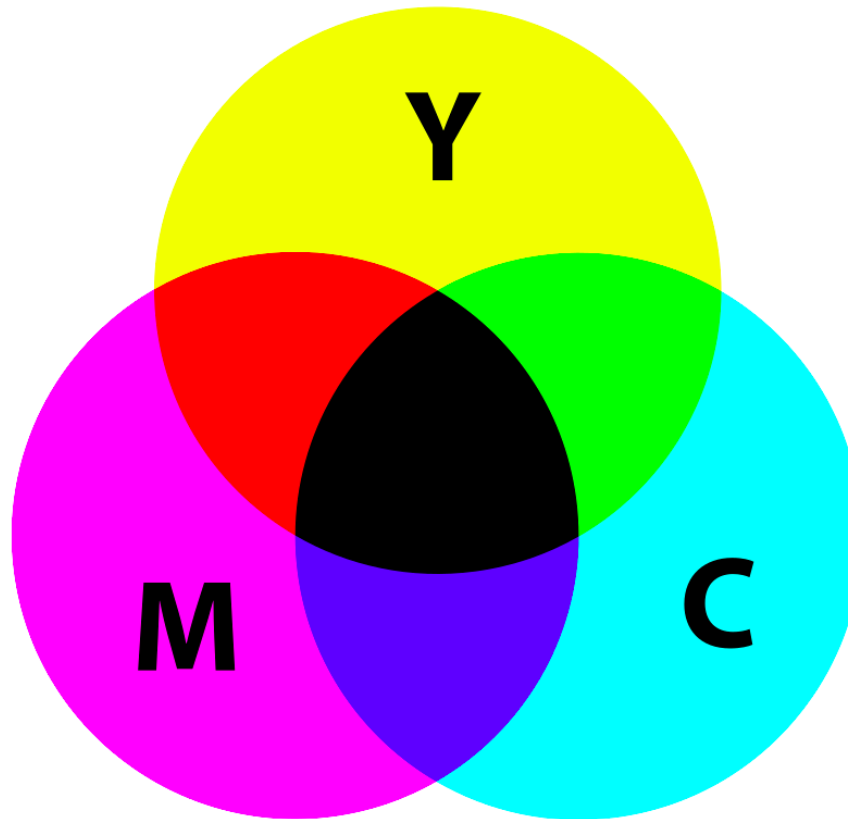
# CMYK Model

- The CMYK color model (also known as process color, or four color) is a subtractive color model, based on the CMY color model, used in color printing, and is also used to describe the printing process itself.
- CMYK refers to the four ink plates used in some color printing: cyan, magenta, yellow, and key (black).

# CMYK Model

- The CMYK model works by partially or entirely masking colors on a lighter, usually white, background.
- The ink reduces the light that would otherwise be reflected. Such a model is called subtractive because inks "subtract" the colors red, green and blue from white light.
- White light minus red leaves cyan, white light minus green leaves magenta, and white light minus blue leaves yellow.

# CMYK Model



# RGB to CMY conversion

- The conversion from RGB to CMY is done using this method.

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 255 \\ 255 \\ 255 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

- Consider you have an color image , means you have three different arrays of RED, GREEN and BLUE. Now if you want to convert it into CMY, here's what you have to do.
- You have to subtract it by the maximum number of levels – 1. Each matrix is subtracted and its respective CMY matrix is filled with result.

# HSV Model

- HSL (for hue, saturation, lightness) and HSV (for hue, saturation, value; also known as HSB, for hue, saturation, brightness) are alternative representations of the RGB color model, designed in the 1970s by computer graphics researchers to more closely align with the way human vision perceives color-making attributes.
- In these models, colors of each hue are arranged in a radial slice, around a central axis of neutral colors which ranges from black at the bottom to white at the top.

# How to use HSV Model?

- The HSV color wheel sometimes appears as a cone or cylinder, but always with these three components:
- Hue - Hue is the color portion of the model, expressed as a number from 0 to 360 degrees:
  - Red falls between 0 and 60 degrees.
  - Yellow falls between 61 and 120 degrees.
  - Green falls between 121 and 180 degrees.
  - Cyan falls between 181 and 240 degrees.
  - Blue falls between 241 and 300 degrees.
  - Magenta falls between 301 and 360 degrees.

# How to use HSV Model?

- Saturation describes the amount of gray in a particular color, from 0 to 100 percent.
- Reducing this component toward zero introduces more gray and produces a faded effect.
- Sometimes, saturation appears as a range from 0 to 1, where 0 is gray, and 1 is a primary color.

# How to use HSV Model?

- Value (or Brightness)
  - Value works in conjunction with saturation and describes the brightness or intensity of the color, from 0 to 100 percent, where 0 is completely black, and 100 is the brightest and reveals the most color.



# Uses of HSV

- Designers use the HSV color model when selecting colors for paint or ink because HSV better represents how people relate to colors than the RGB color model does.
- The HSV color wheel also contributes to high-quality graphics. Although less well-known than its RGB and CMYK cousins, the HSV approach is available in many high-end image editing software programs.
- Selecting an HSV color begins with picking one of the available hues and then adjusting the shade and brightness values.

# Thank you

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## Web Resources

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[contact@mitu.co.in](mailto:contact@mitu.co.in)  
[tushar@tusharkute.com](mailto:tushar@tusharkute.com)