A3 – IMAGE TYPES AND FORMATS

Introduction

Digitized images come in four basic types:

1. **Binary images** are black OR white images, their pixel values are either ones (1's) or zeros (0's) or BITS. Images are saved as binary if the information needed may be found in line shapes. Examples are document text, fingerprints, lineart, particle tracks and signatures. If the image size is 256 □ 256 pixels (short for "picture element"), the size of the image file is 256 □ 256 BITS or 8192 bytes or 8KB.
2. **Grayscale images** are black and white images. Each pixel is given a value between 0 (black) to 255 (white), which means one pixel equals one BYTE. Images are saved as grayscale if the information needed is embedded in gray tones. Examples include, medical or biological images (scanned x-rays, microscope slides) and faces for face recognition. A 256 □ 256 grayscale image is 65,536 bytes large, or 64KB.
3. **Truecolor images** are images with three CHANNELS or BANDS. Each channel is the intensity of a red, green and blue primary light. Color is produced when these three channels are overlaid. The number of possible colors in a truecolor image is 256^3 or 1.6+ million colors. Examples are images taken by commercial digital cameras. A 256 □ 256 truecolor image is 256 □ 256 □ 3 = 196608 bytes large or 192KB (divide the true byte size by 1024 to get the computer byte size).
4. **Indexed images** are colored images whose colors are represented by numbers which denote the index of the colors in a COLOR MAP. Two sets of data are stored in an indexed image, the image and its color map. An indexed image is generally smaller in size compared to a true color image but may have reduced color information.

As more and more advanced imaging techniques and devices are developed, image types have become advanced as well. Some examples include

1. **High dynamic range (HDR) images**. There are special scenes that require more than 8-bit grayscale recording in order to be appreciated. Examples are digital x-rays and very bright objects (nuclear explosion, sun or cloud images, plasma). HDR images can be stored in 10- to 16-bit grayscales.
2. **Multi or hyperspectral image**. These are images that have more bands than 3 (for Red, Green and Blue). A multispectral image has bands in the order of 10's while a hyperspectral image has bands in the order of 100. Example are satellite images.
3. **3D images**. There are many ways of storing spatial 3D information. 3D surfaces may be saved as point clouds (x,y,z), image stacks (2D images of several cross sections, such as MRI or CT SCAN images), stereopairs, (dual images of a scene taken a short distance apart).

4. **Temporal images or Videos.** Although moving pictures have been around since 1870, their digitization, compression and method of capture has advanced dramatically in the advent of smaller and smaller transistors. We now have cheap, high definition, high frame rate digital cameras that can show fast phenomena in slow motion.

Formats

Most commercial cameras will automatically save your images in JPEG format. JPEG stands for "Joint Photographic Expert Group", the association which developed and promoted the image format. You may have encountered other file formats such as *.bmp, *.tif, or *.png, and many others.

In image processing **the choice of image format matters.** As cameras gain more and more pixels, it was realized that images need to be compressed for efficient storage and transmission. There are two formats in which images may be compressed, lossy or lossless.

In **lossy image compression**, not all image information is saved. Depending on the compression settings, a human observer will not mind or not even notice the loss of data. Lossy compression results in a very compact file. Lossy file formats include jpg and gif.

In **lossless image compression**, every pixel information is preserved. This is essential in applications where even a point may mean something. Applications such as medical imaging for clinical diagnosis and archiving of important documents or works of art will need lossless image compression. TIFF (Tagged Image Format) is a lossless compression format. Depending on the settings PNG (portable network graphics) can be lossy or lossless. In addition, PNG can support images stored in more than 8 bits.

Images may need to be converted from one type to another. For example, unless you specify its properties at the start of capture, a scanned image is a true color image before it is saved as a file. When saved, (usually in JPG format) it is converted into an indexed image. For applications such as area calculation, it will need to be converted into grayscale or binary image.

Resolution

Another important image property is resolution, expressed as **dpi** or dots per inch. When using a scanner or when saving an image file, you can specify dpi. In scanned images, the higher the dpi the more you can zoom in on details of the document.

Resolution, however, is ultimately affected by the optics of the capture device. For example, a microscope is diffraction-limited, that is, beyond a certain magnification, you can no longer see finer details.

Higher dpi's result in larger image files. The proper dpi settings depend on the application. For example, it is standard that if you are preparing a figure for a journal paper submission, save the image in 300dpi. This will ensure that once your paper is pdf'ed the images will appear crisp. For image processing, it is enough to save between 72 and 100 dpi.

Thresholding – separating background from region of interest

The region of interest (ROI) in an image may be delineated from the background by thresholding. Generally, the ROI has a different range of colors or grayscales from the background. This can be found from the histogram of the image. The **histogram** of a grayscale image is a plot which represents the number of pixels in an image having a certain grayscale value. The x-axis are the grayscale values and the y-axis are the number of pixels. When normalized to the total number of pixels in the image, the histogram becomes the probability distribution function (PDF) of the image grayscale.

The image is of good contrast if its histogram is well spread across the grayscales. The image is poor or low contrast if the image is confined to a small portion of the available grayscale.

ROI and background are said to be well delineated if the grayscale distribution of the ROI is distinct from the background. In this case, simple thresholding of an image can separate background from ROI.

Procedure

1. Collect images from the web (or from your personal files) of basic and advanced image types. Right-click the file and click “Properties” then “Details”. Copy the details. Note that in some cases even the camera settings are specified. Post these examples and list the image properties.
2. Use any of the following free image processing software: Paint, ImageJ, GIMP or the native image processing software in your computer (wether Linux, OS, or Windows). Look for the following features:
    a. Image Properties
    b. Export or Make a Copy (to save image in different file formats)
    c. Histogram
    d. Crop
3. Pick one true-color image to manipulate. Using any of the free Image Processing software convert the image into a binary, grayscale, and indexed image. Export into a file and comment on the file size and the appearance of the image.
4. Research on the different file formats and give a short writeup on their history and use.
5. In this class you may use Scilab, (installed with SIVP), Matlab, or Python for programming. Explore the use of the following commands (use Help) : **imread, imwrite, imshow, imfinfo (or similar command to display image properties), hist (or similar commands to plot the image histogram, rgb2gray (or similar commands to convert a truecolor image to grayscale.**