

# 02-on-images

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## 1 We need to talk about images

### 1.1 Images are numbers organized in a grid

- Image is composed of pixels:

### 1.2 Number representations

- 1 bit: 0 or 1 (False or True) *aka* boolean
- 8 bit integer
- signed: -128 to 127 *aka* int8
- unsigned: 0 to 255 *aka* uint8
- 16 bit inger
- signed: -32768 to 32767 *aka* int16
- unsigned: 0 to 65535 *aka* uint16

### 1.3 Coordinate system

#### 1.3.1 Image = Table

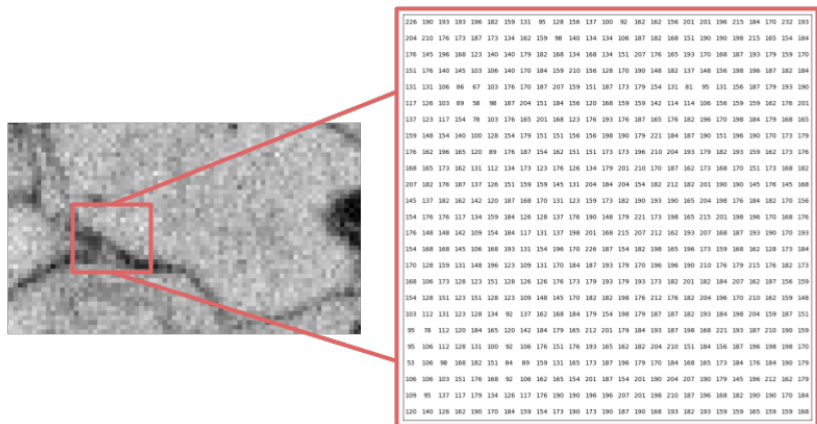
- numbers are organized in a grid
- like a table an image has *rows* and *columns*
- *row* and *column* indices start at 0
- origin is in the **top-left** corner

(puppy photo by Joe Caione on Unsplash)

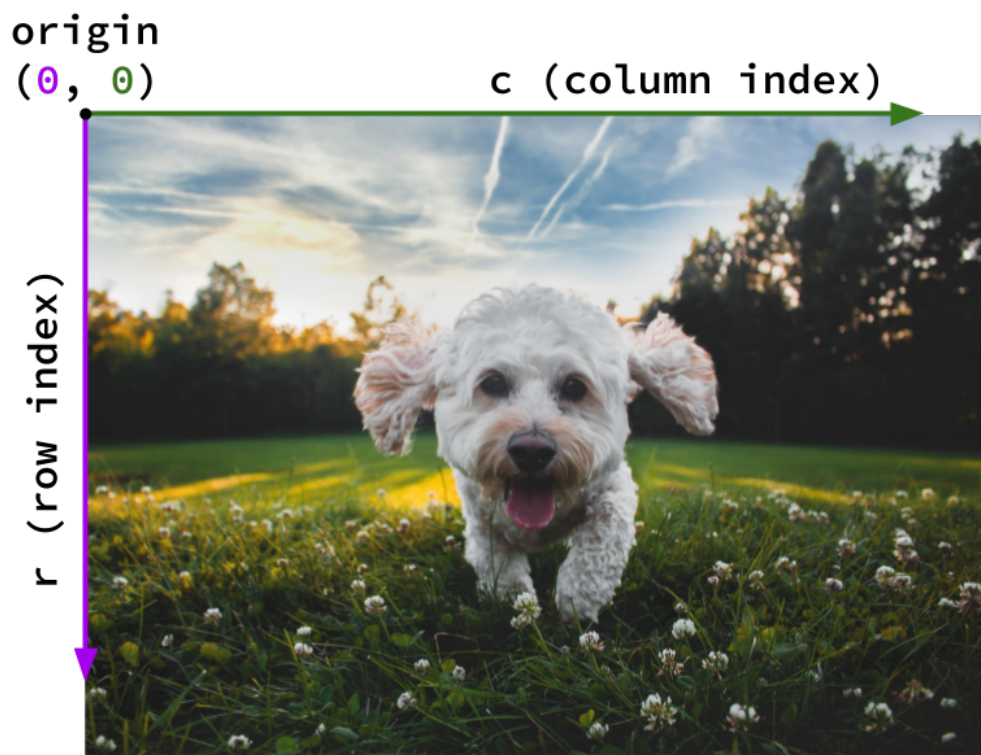
#### 1.3.2 What about x and y (and z)?

- using x and y to specify positions is very common, too (e.g. have a look at fiji).
- We'll use r and c throughout this course
- r corresponds to 'y'
- c corresponds to x

**BEWARE:** coordinates in x-y form are usually given in (x, y) order. In r-c coordinates, we use the (r, c) order.



Images and Numbers



coordinates

## 1.4 Image Channels

- more than just a single value per pixel
- -> multiple images stacked on top of each other
- e.g. from multiple flurophores
- also from different modalities after alignment
- can be presented/viewed as different colors

### 1.4.1 RGB as a special case

- additive *color model* where colors are composed of primary colors red, green and blue
- each primary color stored in a separate channel, so 3 values per pixels are stored
- each value can be in the range of  $[0 \dots 255]$
- software for viewing recognizes this and interprets the triplets to generate a color mixture

### 1.4.2 Exercise: Thinking about RGB colors

Suppose that we represent colors as triples  $(r, g, b)$ , where each of  $r$ ,  $g$ , and  $b$  is an integer in  $[0, 255]$ . What colors are represented by each of these triples?

1.  $(255, 0, 0)$
2.  $(0, 255, 0)$
3.  $(0, 0, 255)$
4.  $(255, 255, 255)$
5.  $(0, 0, 0)$
6.  $(128, 128, 128)$

## 1.5 Compression

### 1.5.1 Lossless Compression

- Algorithm that reorganizes the data in a more efficient way when saving
- When loading the image, the reverse of the algorithm has to be applied
- Reversing the compression process results in a file that is *identical* to the original

### 1.5.2 Lossy Compression

- Algorithm that throws away some detail of the data when saving
- Level of detail that is discarded can be adjusted
- Original image can never be reconstructed again

## 1.6 Image formats

### 1.6.1 Components of an image file

- image data (numbers)
- uncompressed/compressed
- dimensions
- data-type (optional)

- meta-data (optional)
- pixel size (physical)
- channel names
- calibration
- software-specific values
- ...

## 1.7 Image formats summary

	Format	Compression	Metadata	Advantages	Disadvantages
<b>TIFF</b>	None, lossy, or lossless	Yes	High quality or smaller file size		Not universally viewable sooo many flavors
<b>PNG</b>	lossless	yes	Universally viewable, high quality		Large file sizes for natural images
<b>JPEG</b>	Lossy	Yes	Universally viewable, smaller file size		Detail may be lost

- **TIFF**: Tagged Image File Format
- **PNG**: Portable Network Graphics
- **JPEG**: Joint Photographic Experts Group