02-on-images

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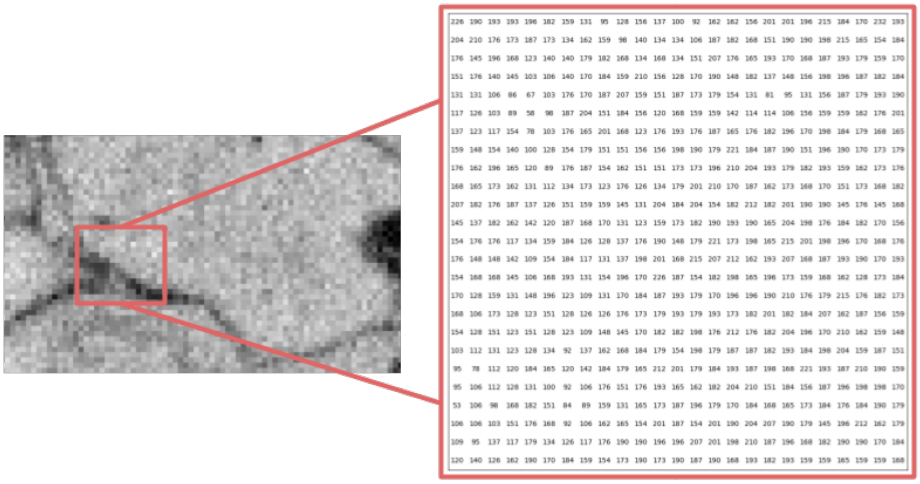
1 We need to talk about images

1.1 Images are numbers organized in a grid

- Image is composed of pixels:



1.2 Number representations

1.2.1 There are `10` types of people: those who understand binary and those who dont.

1.2.2 1 Bit

```
0  -> 0
1  -> 1
```

1 bit: `0` or `1` (`False` or `True`) *aka* boolean

1.2.3 2 Bits

```
0 0  -> 0
0 1  -> 1
1 0  -> 2
1 1  -> 3
```

2 bits can encode 4 numbers

1.2.4 There are `10` types of people: those who understand binary and those who dont.

1.3 Common number representations for images

- float: `-42.0 ... -2.4345 ... 3.4562 ...`
- integer: `-42 ... -2 ... 3 ...`
- `8 bit integer`
  - signed: `-128` to `127` *aka* `int8`
  - unsigned: `0` to `255` *aka* `uint8`
- `16 bit integer`
  - signed: `-32768` to `32767` *aka* `int16`
  - unsigned: `0` to `65535` *aka* `uint16`

1.4 Coordinate system

1.4.1 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)

1.4.2 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.

1.5 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

1.5.1 RGB as a special case

- additive *color model* where colors are composed of primary colors **r**ed, **g**reen and **b**lue
- each primary color stored in a separate channel, so 3 values per pixels are stored
- each value can be in the range of `[0..255]`
- software for viewing recognizes this and interprets the triplets to generate a color mixture

1.5.2 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)

1.6 Compression

1.6.1 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

1.6.2 Lossy Compression

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

1.7 Image formats

1.7.1 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
- ...

1.8 Image formats summary

Format	Compression	Metadata	Advantages	Disadvantages
TIFF	None, lossy, or lossless	Yes	High quality or smaller file size	Not universally viewable sooo many flavors
PNG	lossless	yes	Universally viewable, high quality	Large file sizes for natural images
JPEG	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