Visual Analytics

Session 2: Basic Image Processing

Ross Deans Kristensen-McLachlan
rdkm@cas.au.dk

Course outline

- 1. Introducing Visual Analytics
- **2. Basic image processing**
- 3. More image processing
- 4. Convolutional kernels
- 5. Image classification 1
- 6. Image classification 2
- 7. From shallow to deep learning
- 8. Convolutional neural networks
- 9. Pretrained CNNs and transfer learning
- 10. Image embeddings
- 11. Project presentations
- 12. Text-to-image models
- 13. Project development

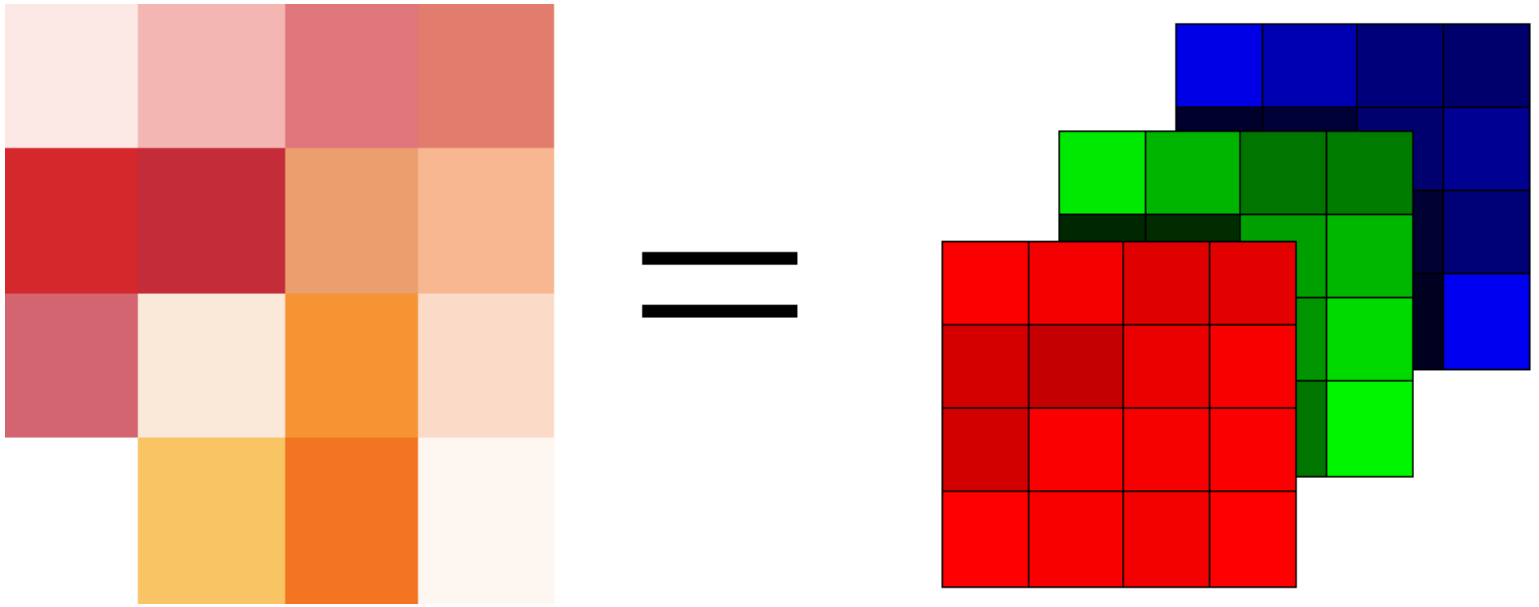
Plan for today

- No assignment from last week

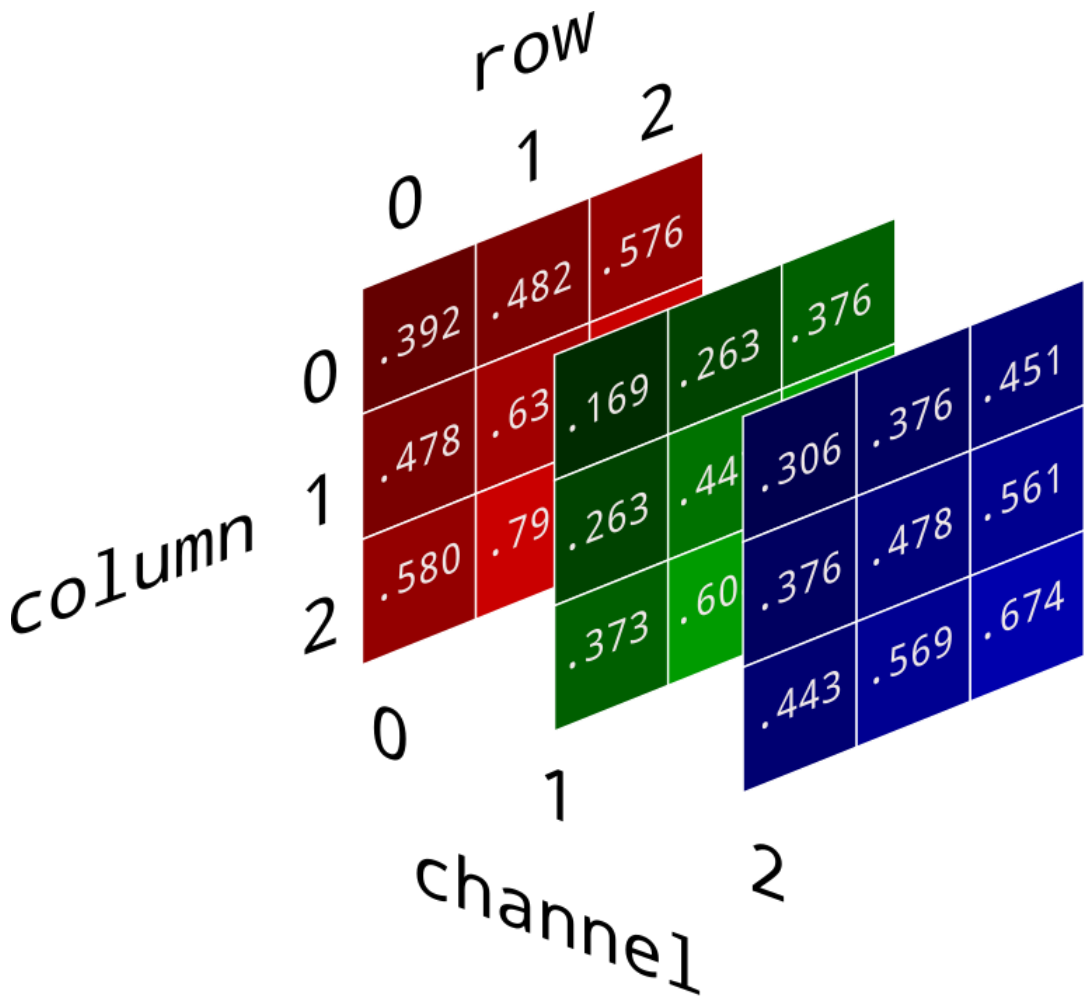
- 1. Basic image processing
  - Thinking about colour channels
  - Introducing histograms

- 2. Code-along session
  - More on OpenCV functionality
  - Extracting colour histograms

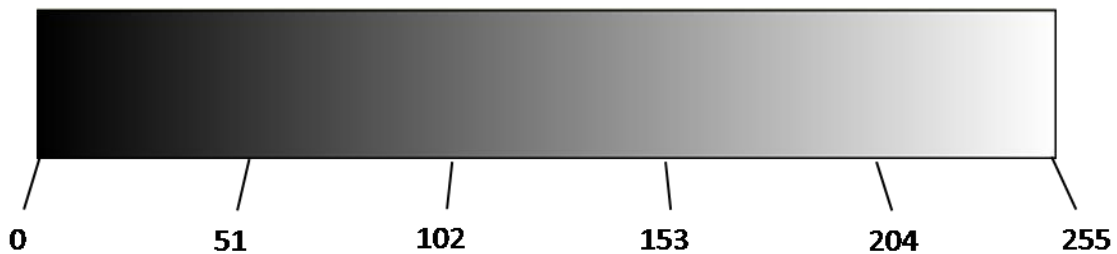
Colour channels

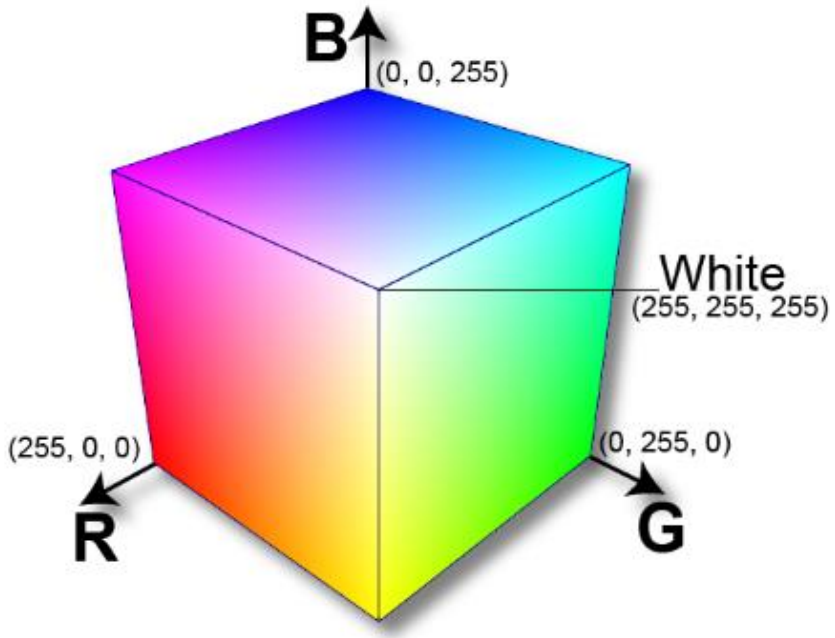


Colour channels



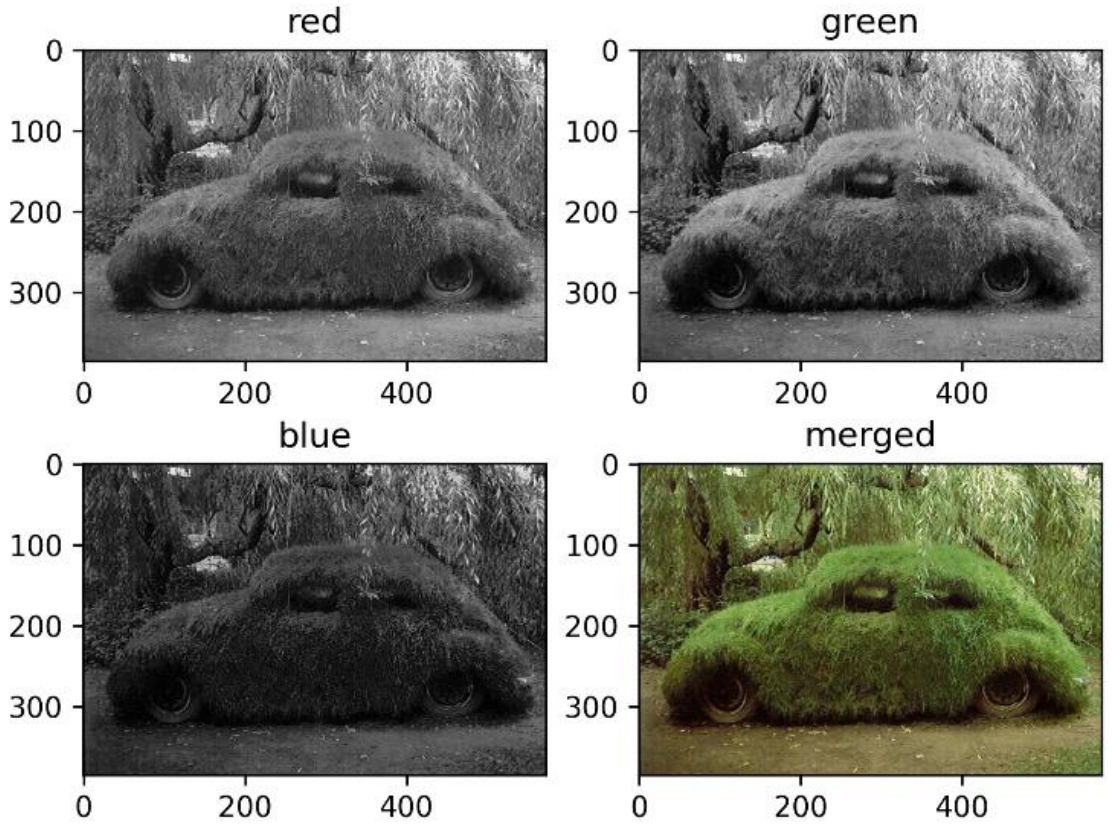
Colour channels





RGB color model which, typically, represents each channel as 8-bit unsigned integers.

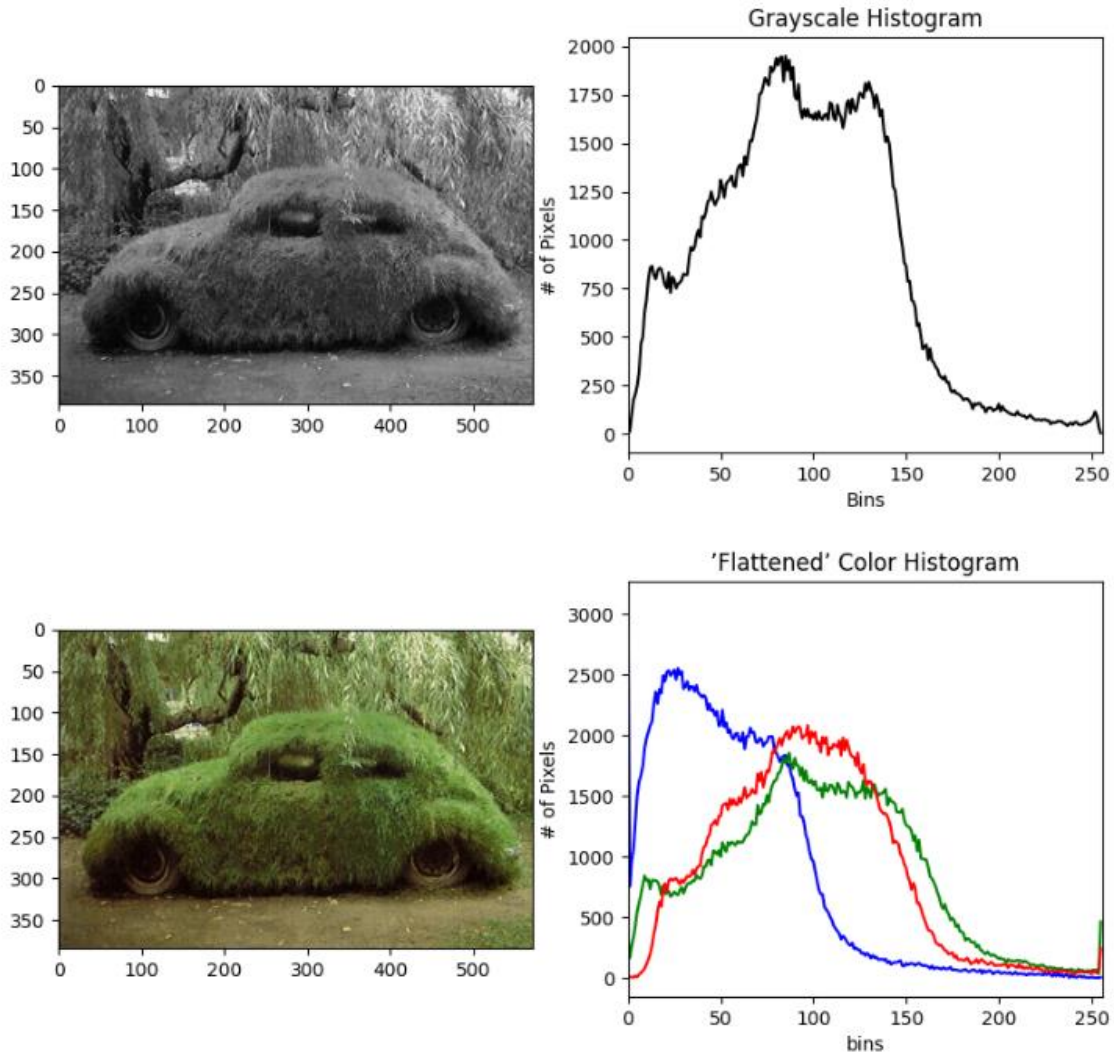
Splitting channels



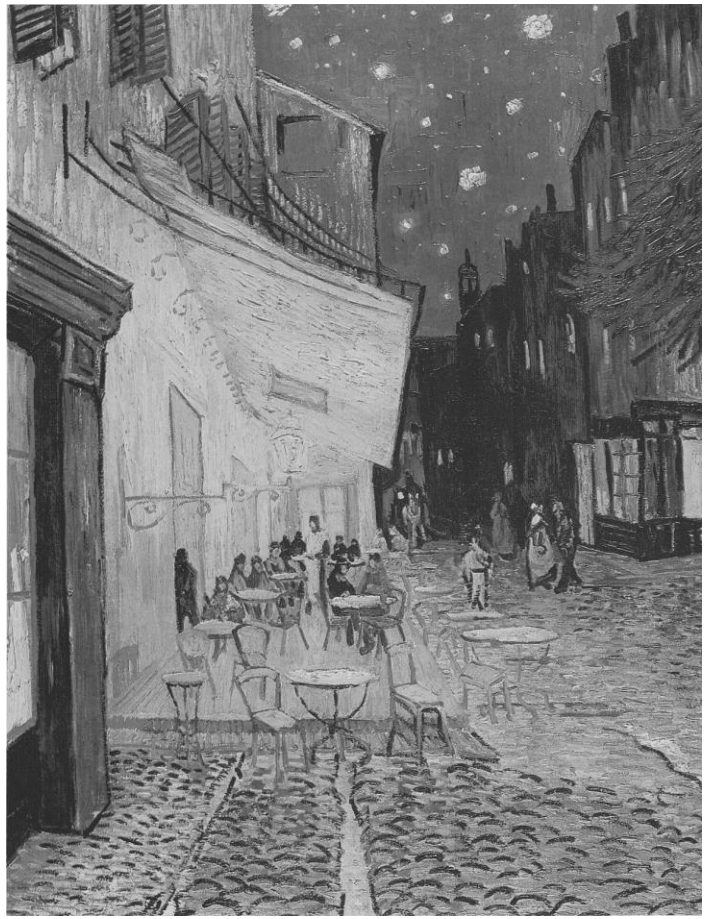
Histograms

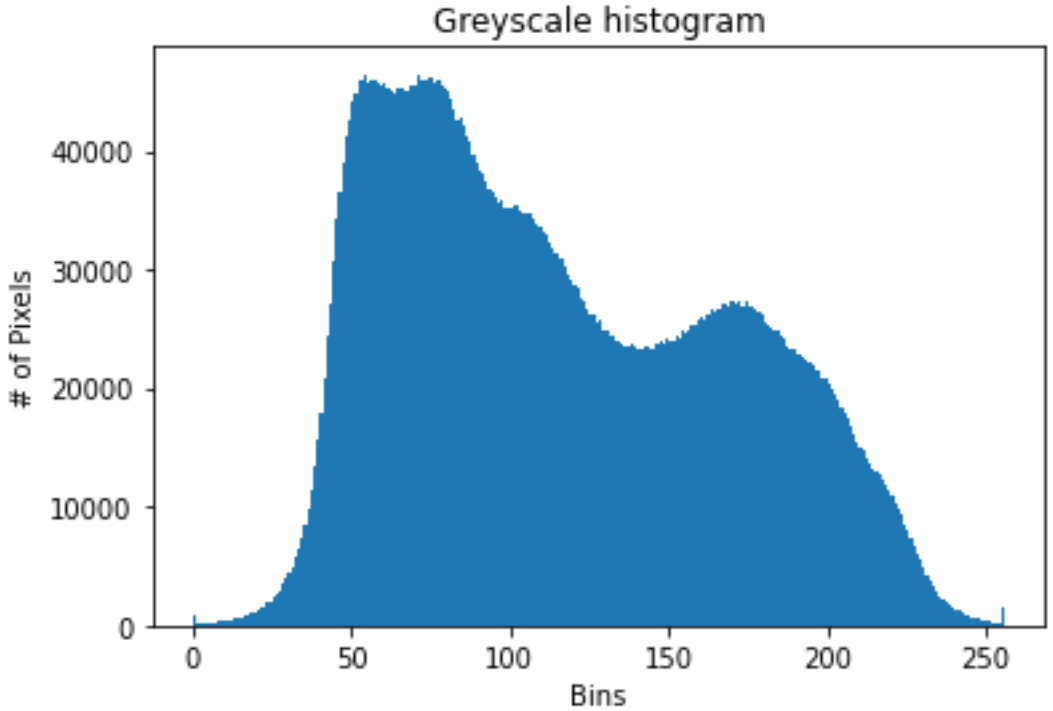
- Represents the distribution of pixel intensities (whether colour or gray-scale) in an image
- Can be visualized with a plot that gives easy-to-understand intuition of the intensity (pixel value) distribution in an image
- Think of it as the ’colour fingerprint’ of an image
- X-axis indicates the range of values the variable can take, divided into a series of intervals called **bins**. The y-axis shows how many values fall within that bin

Plotting histograms

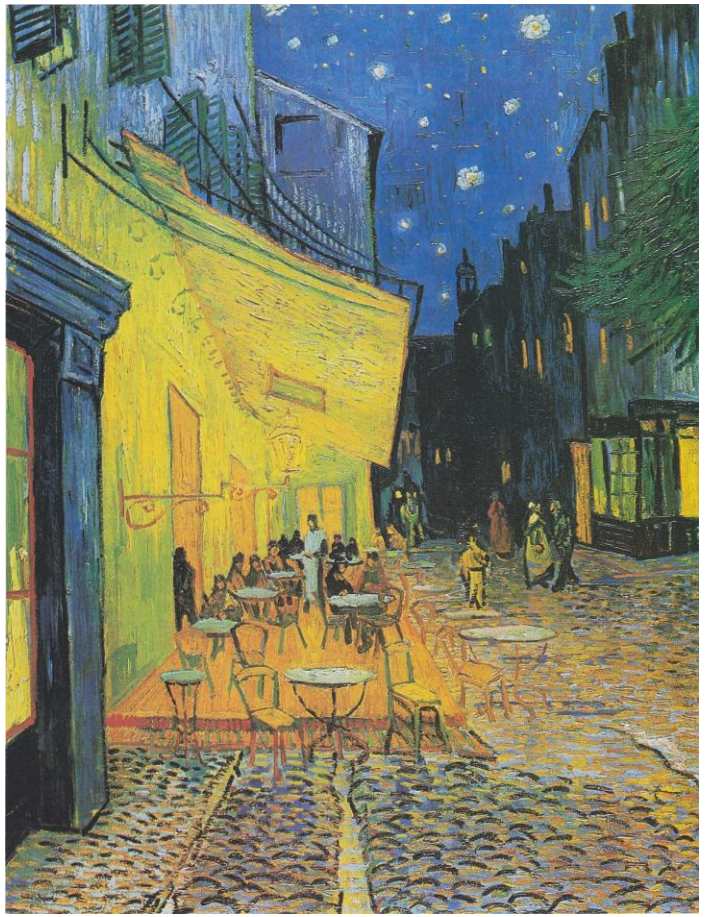


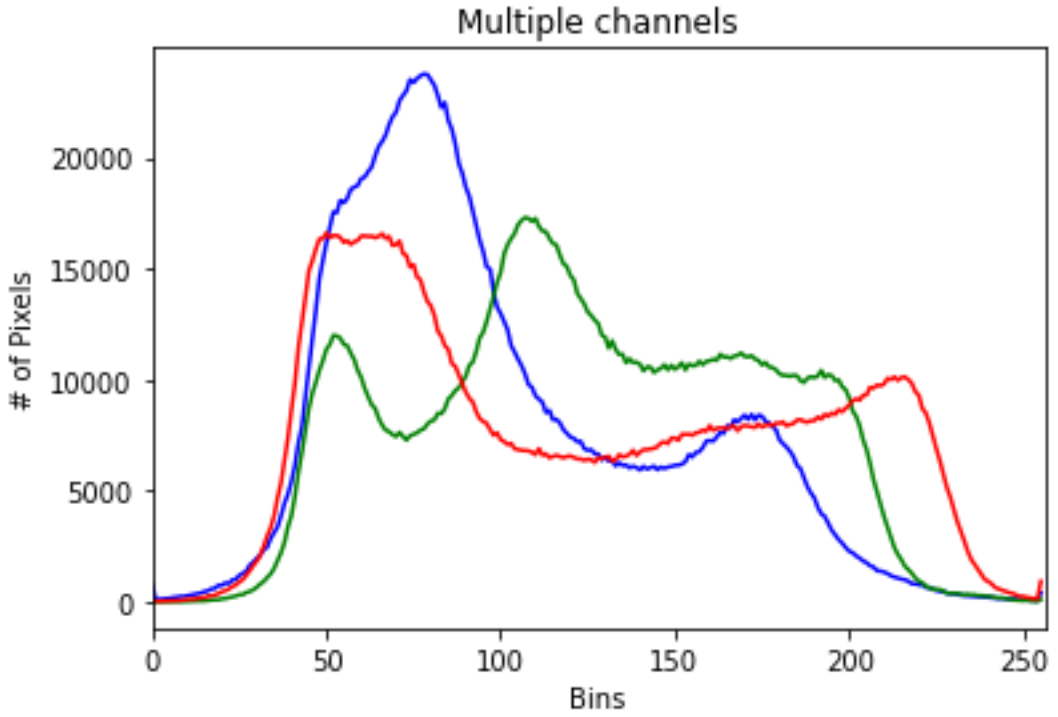
Greyscale histogram





Colour histograms – 1D



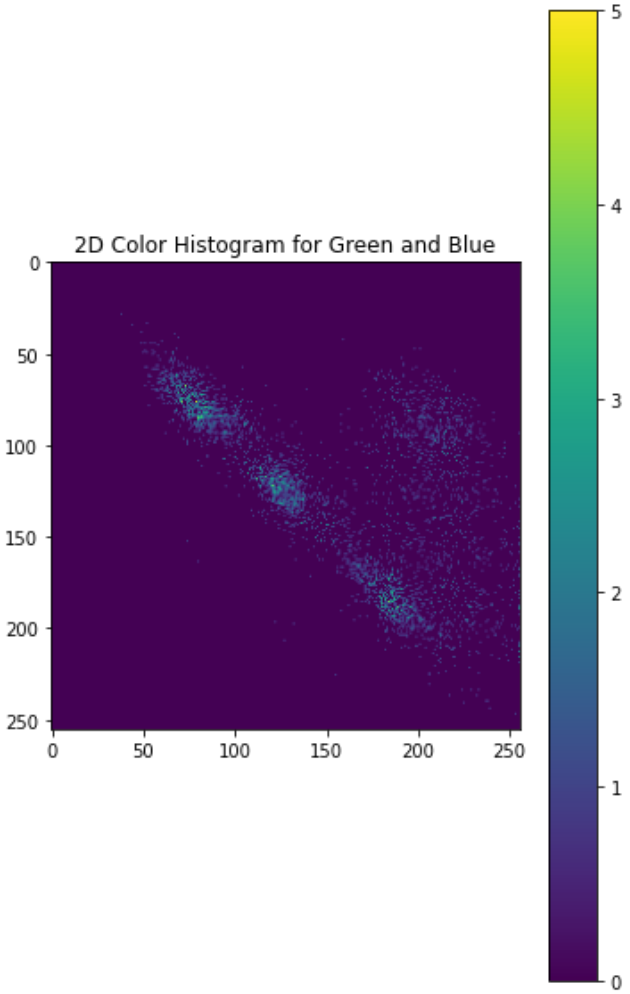


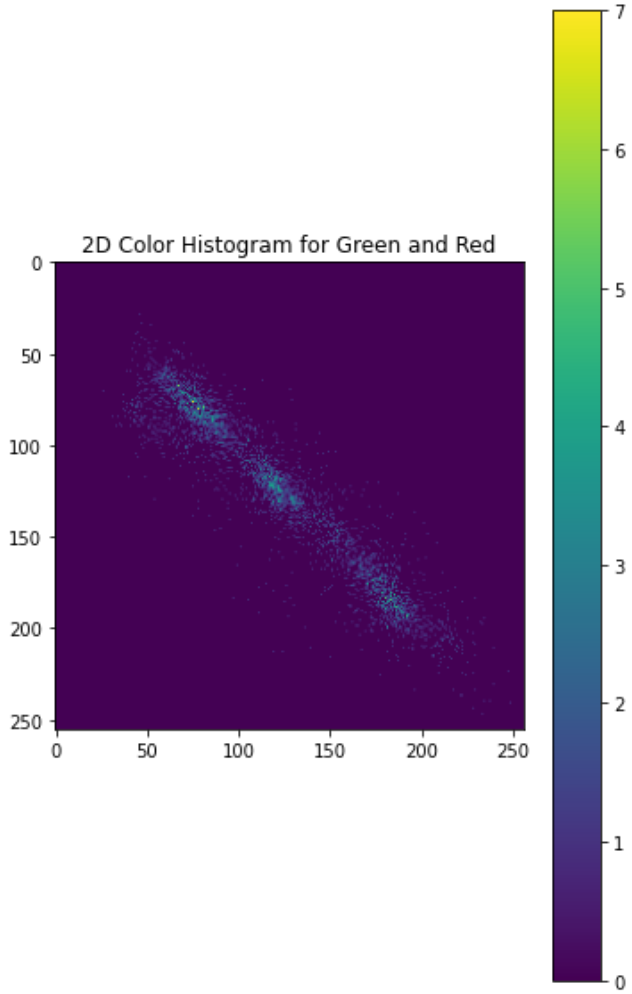
Colour histograms – 2D

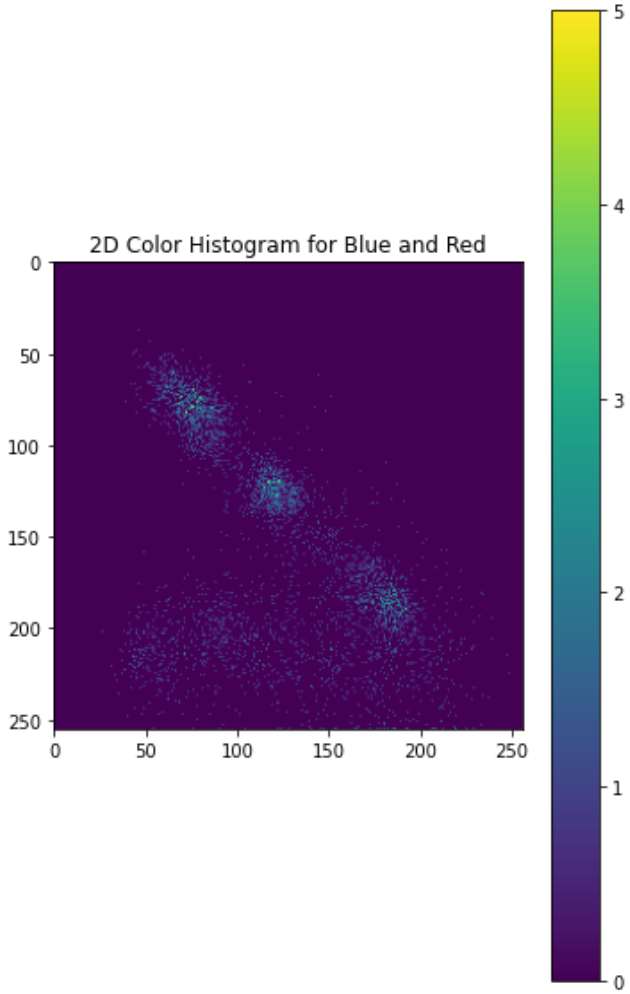
- So far we've only looked at 1-dimensional histograms
  - Greyscale
  - RGB channels
- We could compare images based on 1D histograms
  - Perhaps not very informative?
- What about if we wanted to combine channels?

Colour histograms – 2D

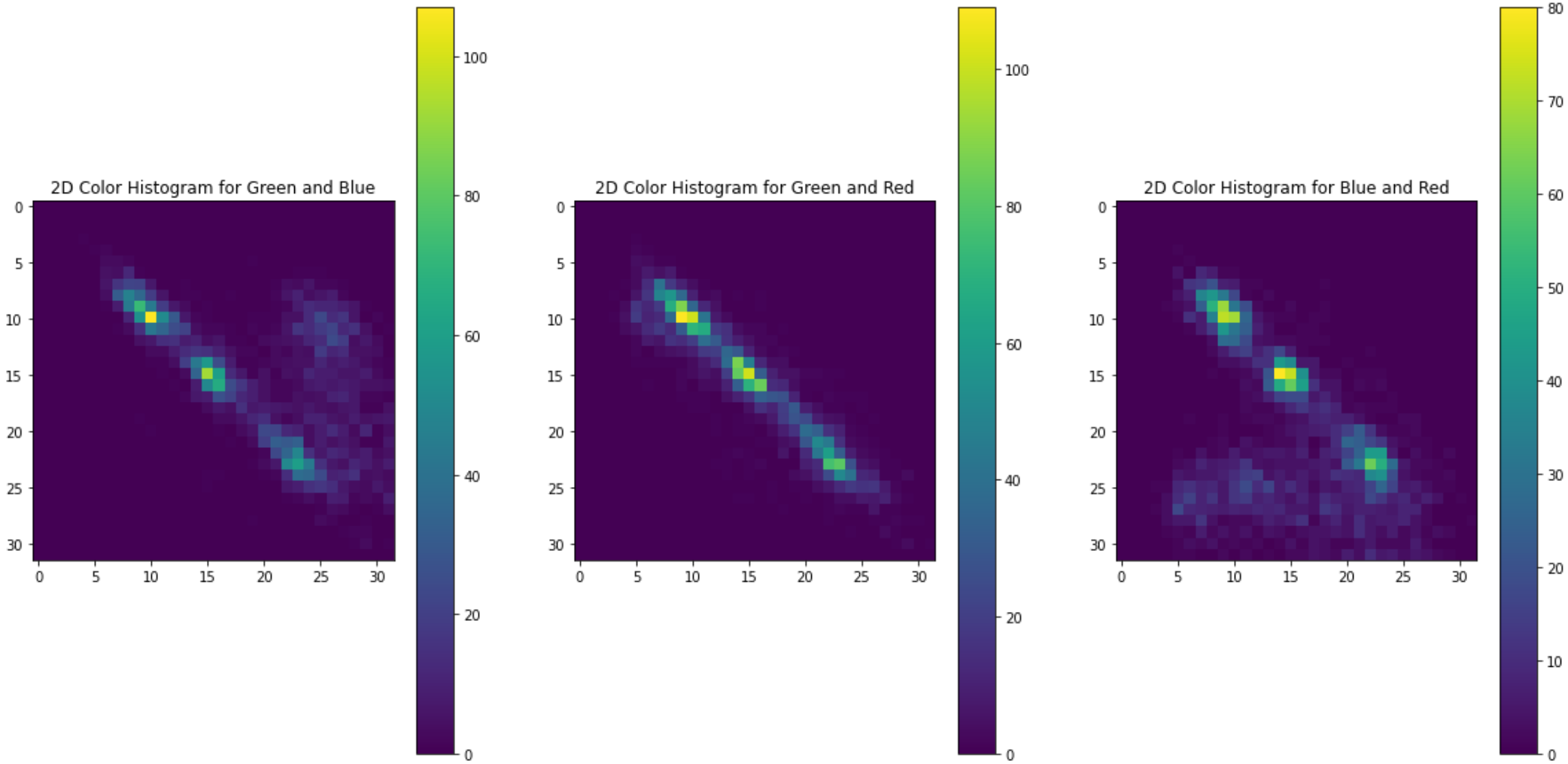
Colour histograms – 2D







Colour histograms – 2D

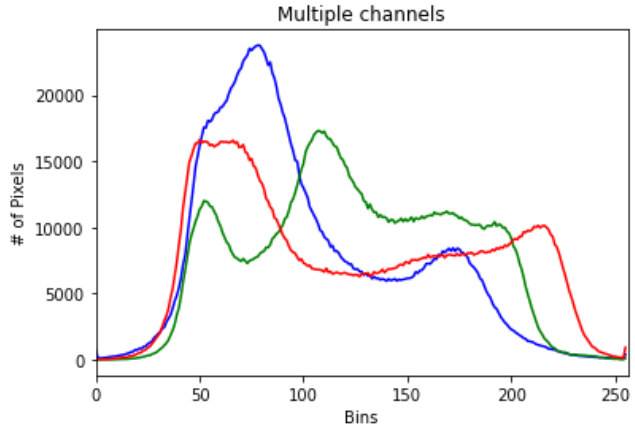


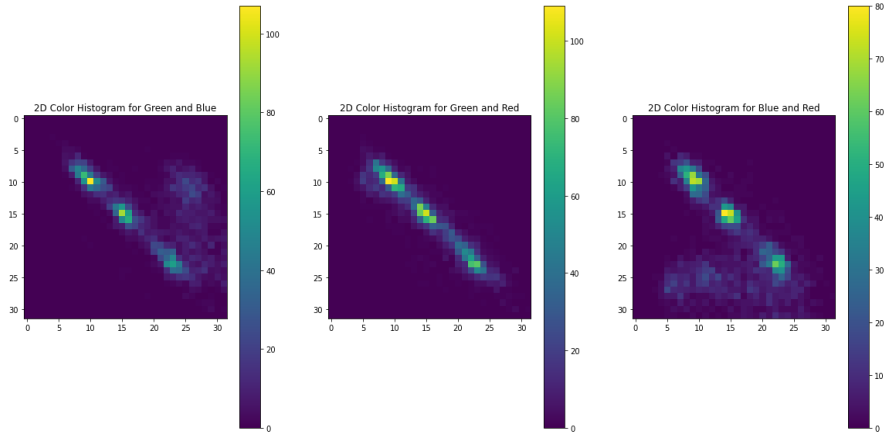
Using bins of 32 x 32

Colour histograms – 2D

- A 1D histogram shows number of number of pixels of a given intensity on a particular channel

- A 2D histogram shows the occurrence of *combinations of intensities*
  - I.e. how many pixels have R = 120, G =100; or G = 50, B = 200; etc





Colour histograms – 3D

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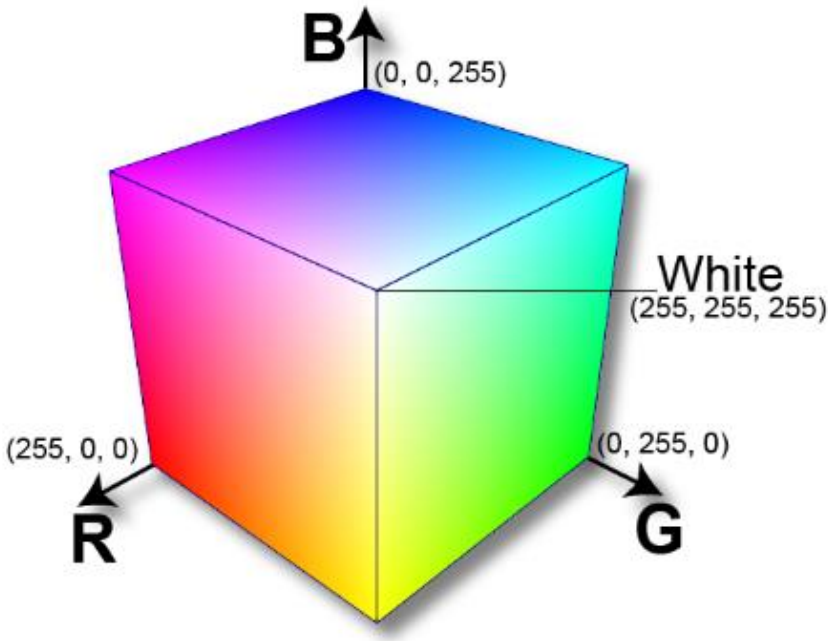
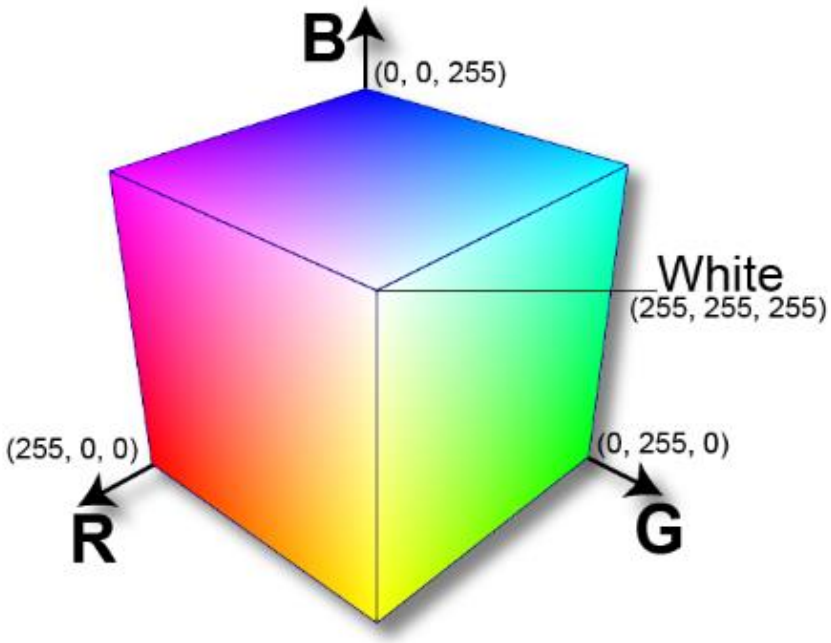
- Think about the RGB model of colour space



RGB color model which, typically, represents each channel as 8-bit unsigned integers.

Colour histograms – 3D

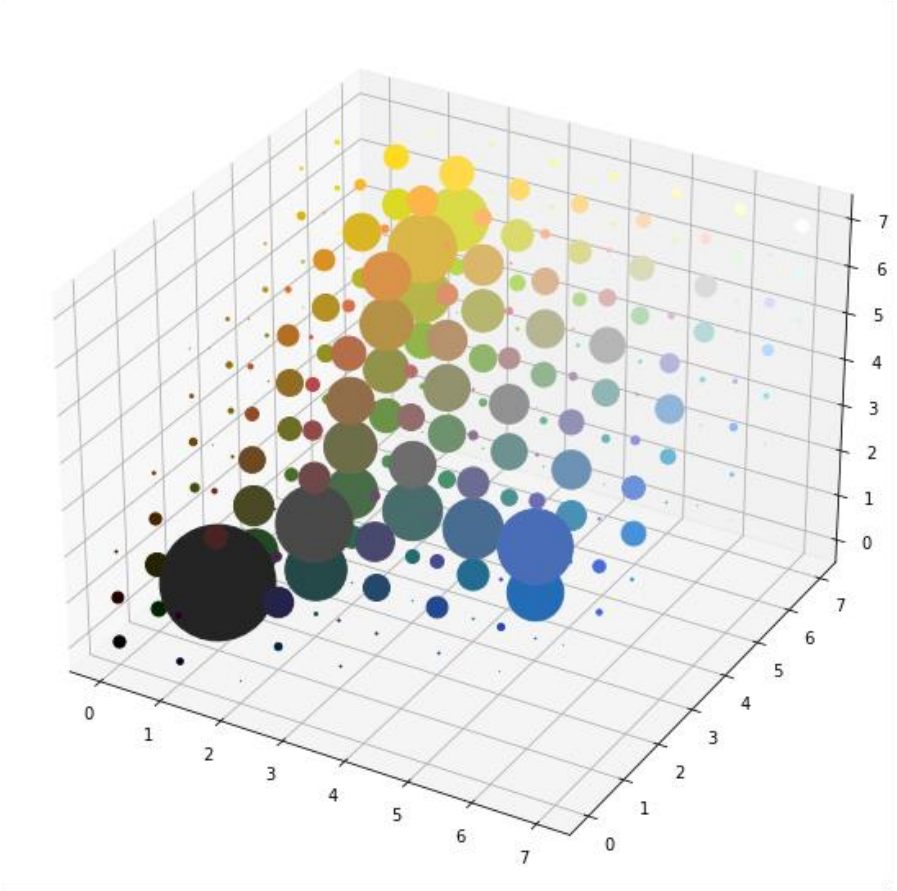
- Not very intuitive to visualise!
- Think about the RGB model of colour space
- Every colour is point in a cube
- 3D histogram shows number of pixels at each point in the cube
  - 256*256*256 = 16,777,216 possible values!



RGB color model which, typically, represents each channel as 8-bit unsigned integers.

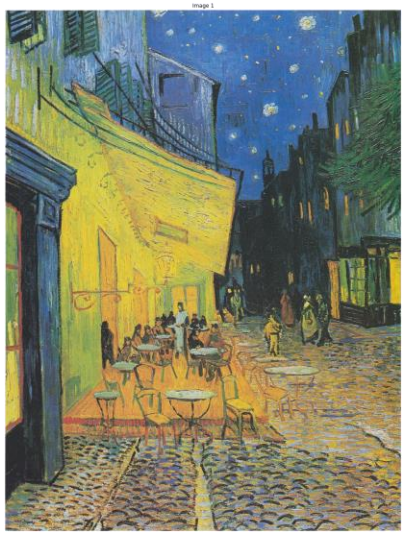
Colour histograms – 3D

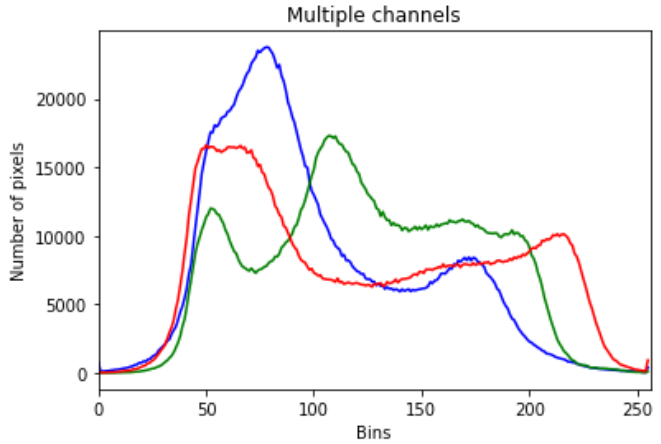
- One possible way of visualising
  - Not perfect but helps with conceptualisation!
- Notice that this 3D histogram uses only 8 bins
  - 8*8*8 = 512 possible values
- Why would we do this?

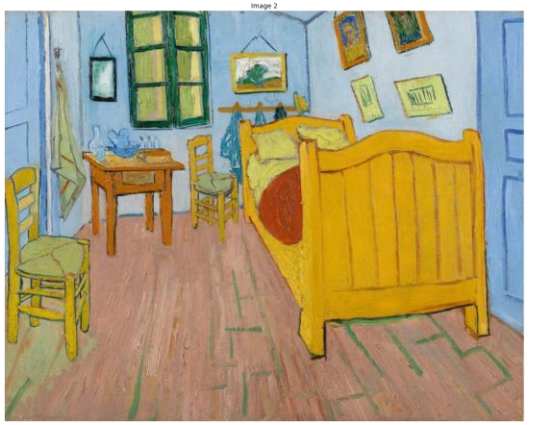


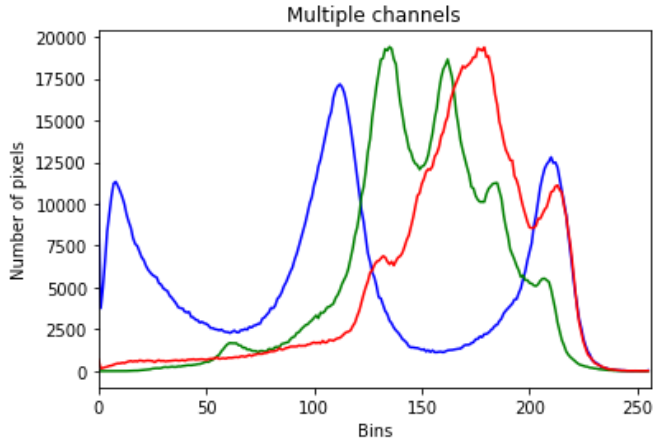
Comparing histograms

- A crucial point is that different images have different colour histograms
- A colour histogram is like the colour *fingerprint* of an image
- We can us this to qualitatively evaluate an image by thinking about the range and interaction between pixel intensities across all three channels
- This also allows us to more precisely describe the difference between more than one image







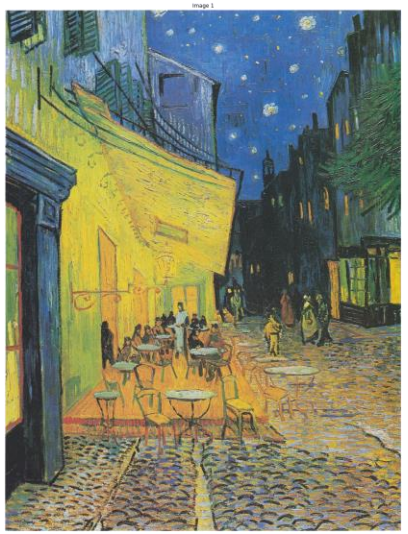


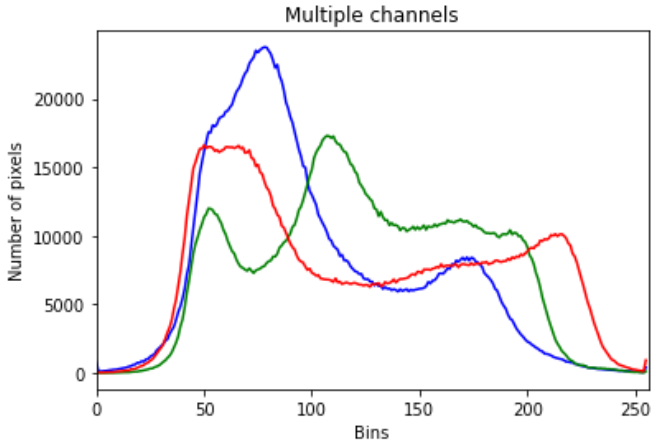
Comparing histograms

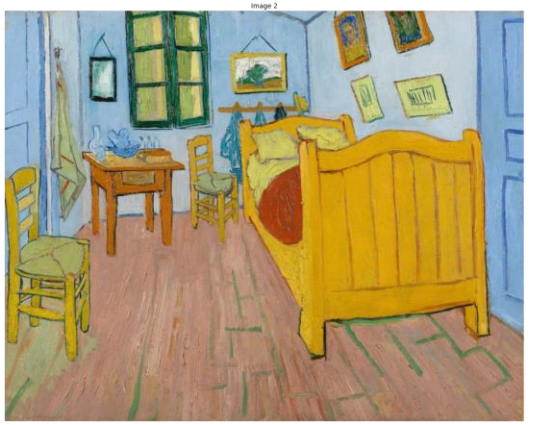
- We can also *quantify the difference* between two histograms
- This allows us calculate the *distance* between two histograms
- Images which are more similar (in terms of colour) will be calculated as being more similar
- OpenCV has a number of different tools to do this, like the Chi Square metric:

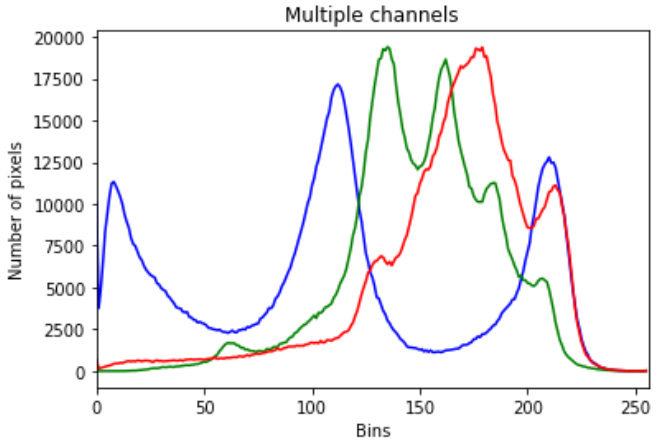
$$d(H_1, H_2) = \sum_I \frac{(H_1(I) - H_2(I)^2}{H_1(I)}$$

- where *I* is the histogram for each channel









Summarising histograms

- Histograms allow us to plot the number of pixels of a particular intensity in a given image
- For a greyscale image (1-channel), we have a single histogram; colour images (3-channels) have a plot line for each channel individually
- We can also visualise how different pixel intensities interact with one another *across* channels
  - Along 2 different dimensions or perhaps even 3
- This allows us to *qualitatively* analyse and evaluate the colour space of one or more images in quite a nuanced manner
- However, we can also compare histograms *quantitively*, using some reasonably simple metrics available through libraries like OpenCV

Break

And head over to UCloud