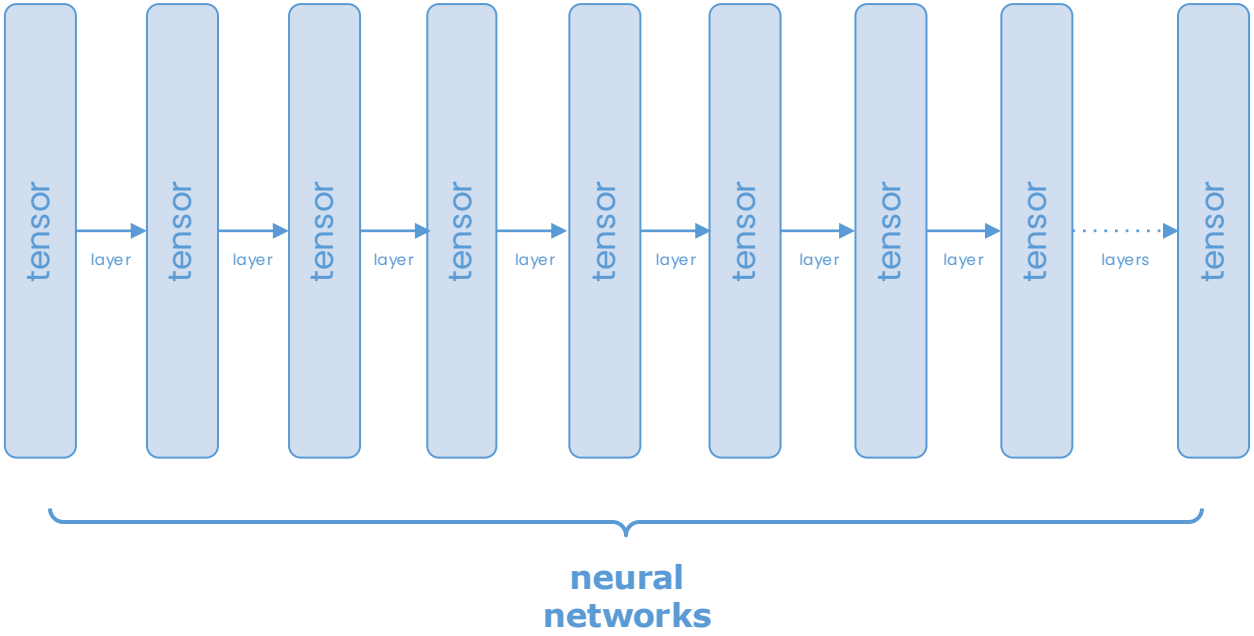
Insper

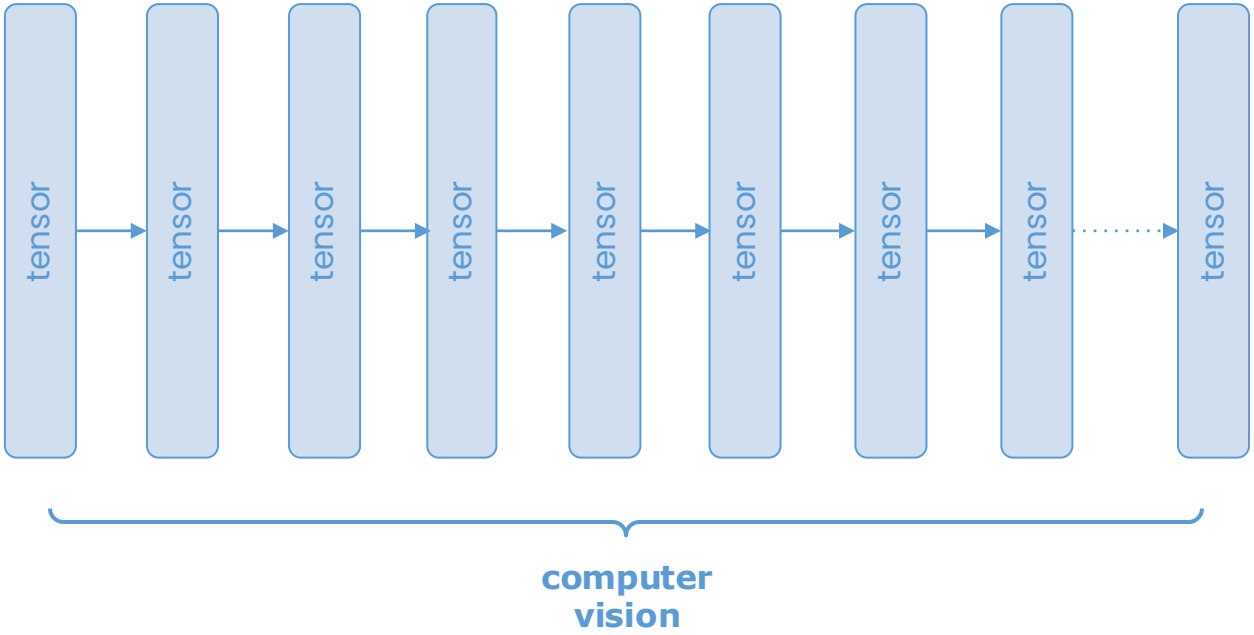
Computer Vision

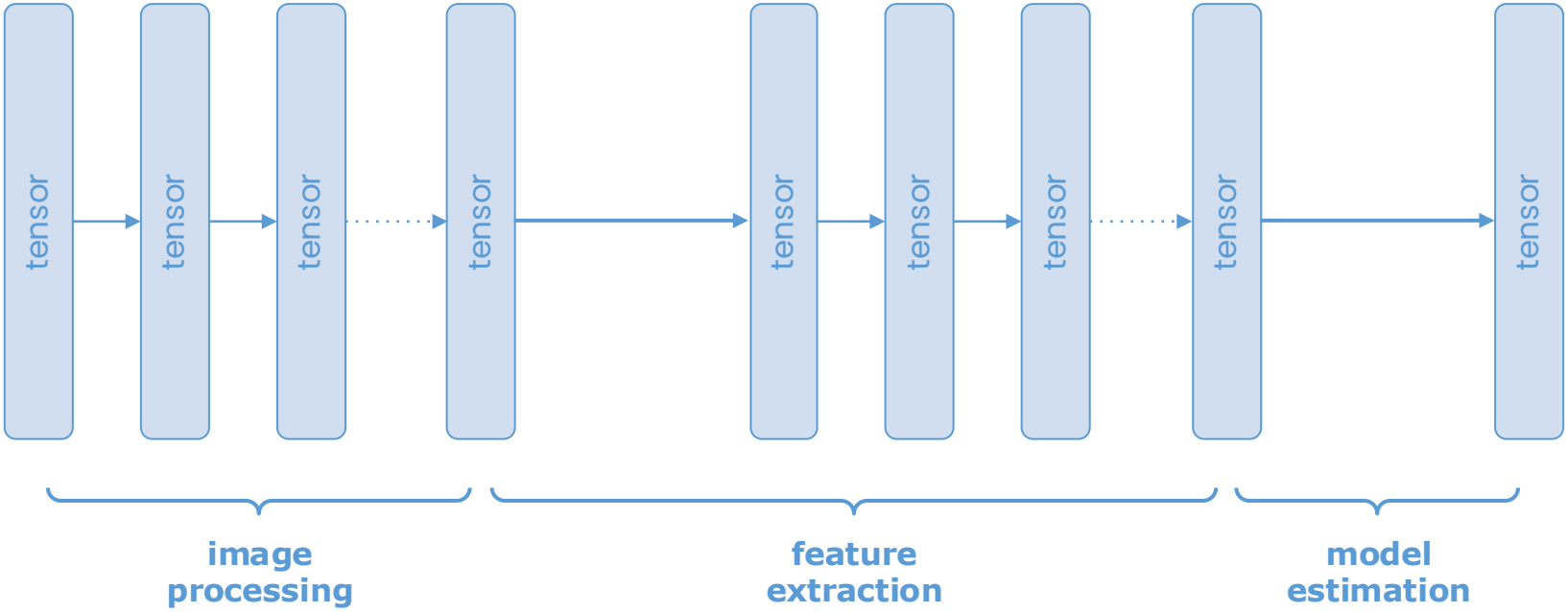
Class 3: Color Perception and Color Models

Neural network mysteries

- How can we separate a dataset in training data and testing data?
- What is a hidden layer?
- Does it matter if the input tensors are 3D, 2D, or 1D?
- What is a dense layer?
- How do we calculate the number of parameters in a dense layer?
- How do we calculate the number of steps in a training process?
- How do we calculate the number of steps in a testing process?
- Does the number of layers matter?
- Does the size of a dense layer matter?
- What exactly `activation='relu'` does?


tensor
layer
tensor
layer
tensor
layer
tensor
layer
tensor
layer
tensor
layer
tensor
layer
tensor
layers
tensor
neural
networks


tensor
tensor
tensor
tensor
tensor
tensor
tensor
tensor
tensor
computer vision


tensor
tensor
tensor
tensor
tensor
tensor
tensor
tensor
tensor
image processing
feature extraction
model estimation

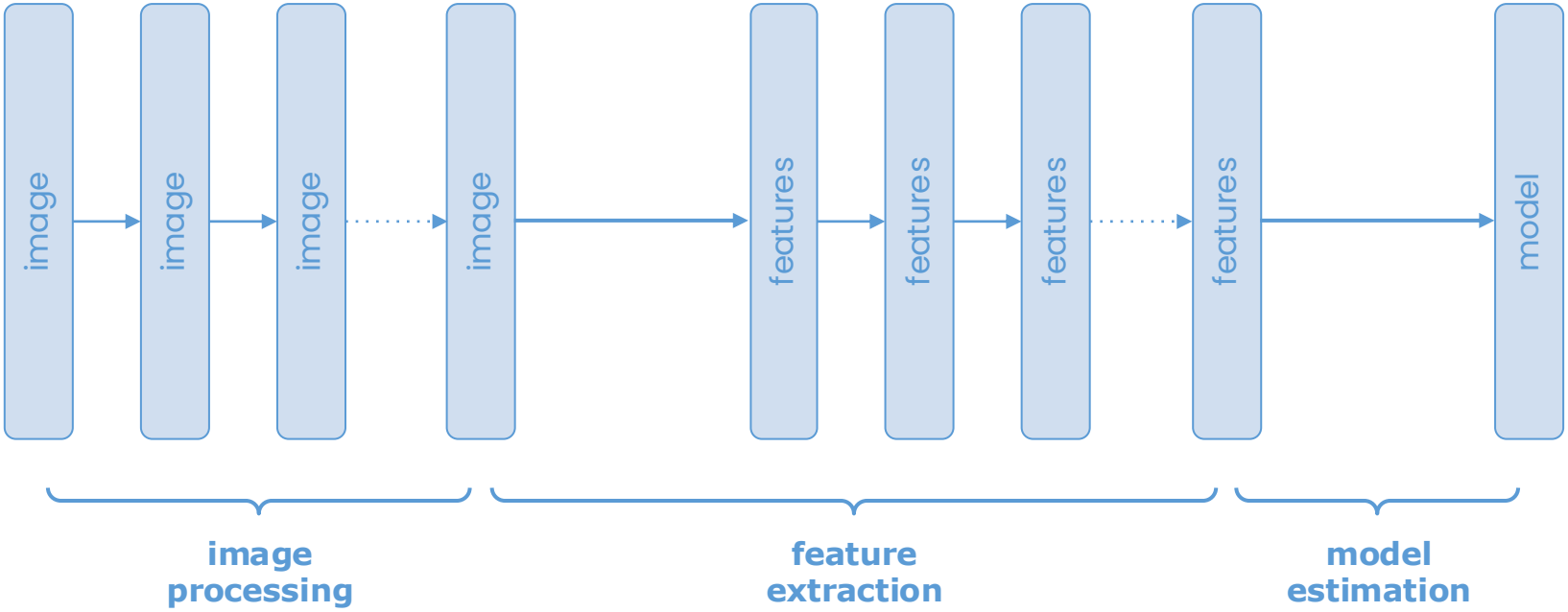


image
image
image
image
features
features
features
features
model
image processing
feature extraction
model estimation

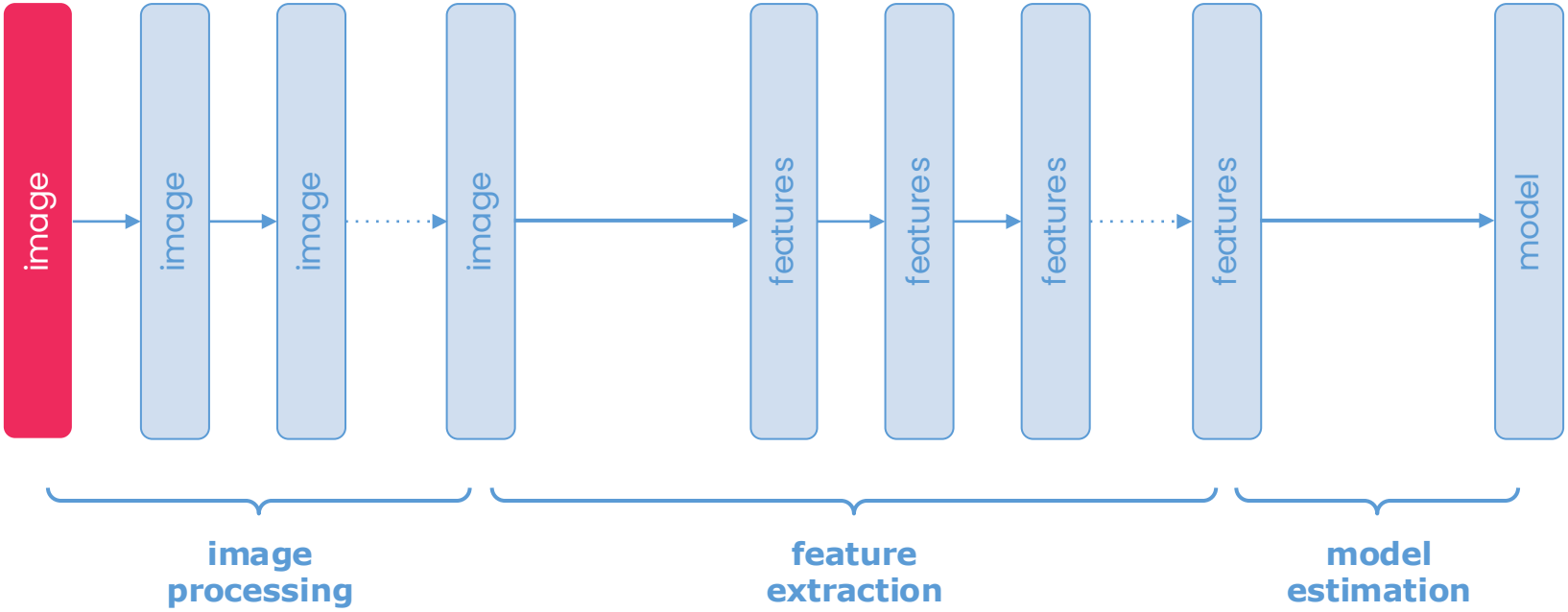
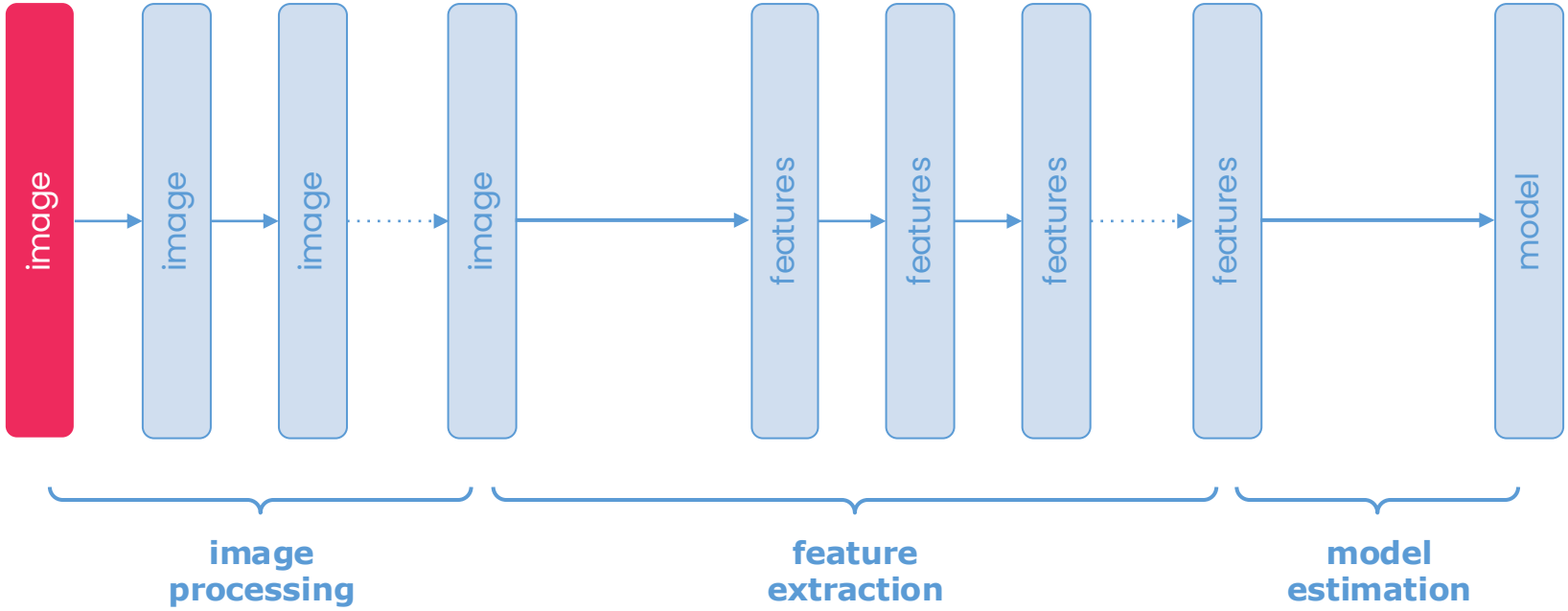


image
image
image
image
features
features
features
features
model
image processing
feature extraction
model estimation

We know that images are simply arrays of numbers...

...but how can we represent colors (not just gray levels) as numbers?

image representation



Data tensor:

a multidimensional array that represents an input or an output

single-channel

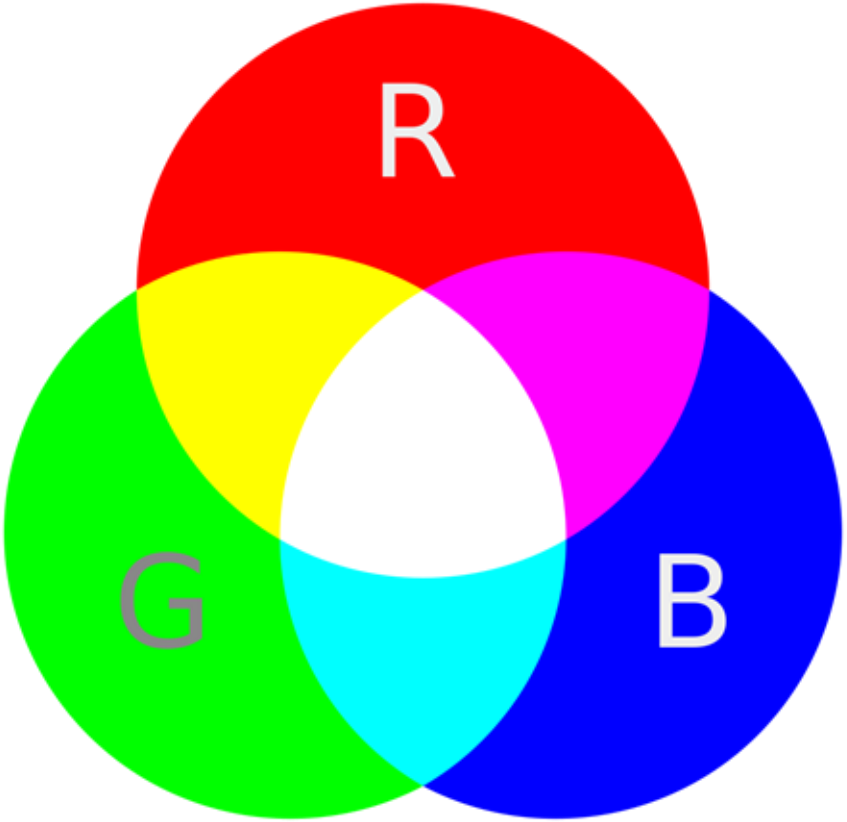
```
[[197, 198, 199, ..., 194, 194, 195],
 [198, 198, 196, ..., 195, 193, 194],
 [197, 197, 196, ..., 196, 193, 194],
  ...,
 [182, 182, 179, ...,  67,  61,  66],
 [187, 187, 181, ...,  80,  76,  76],
 [187, 186, 183, ...,  91,  94,  97]]
```

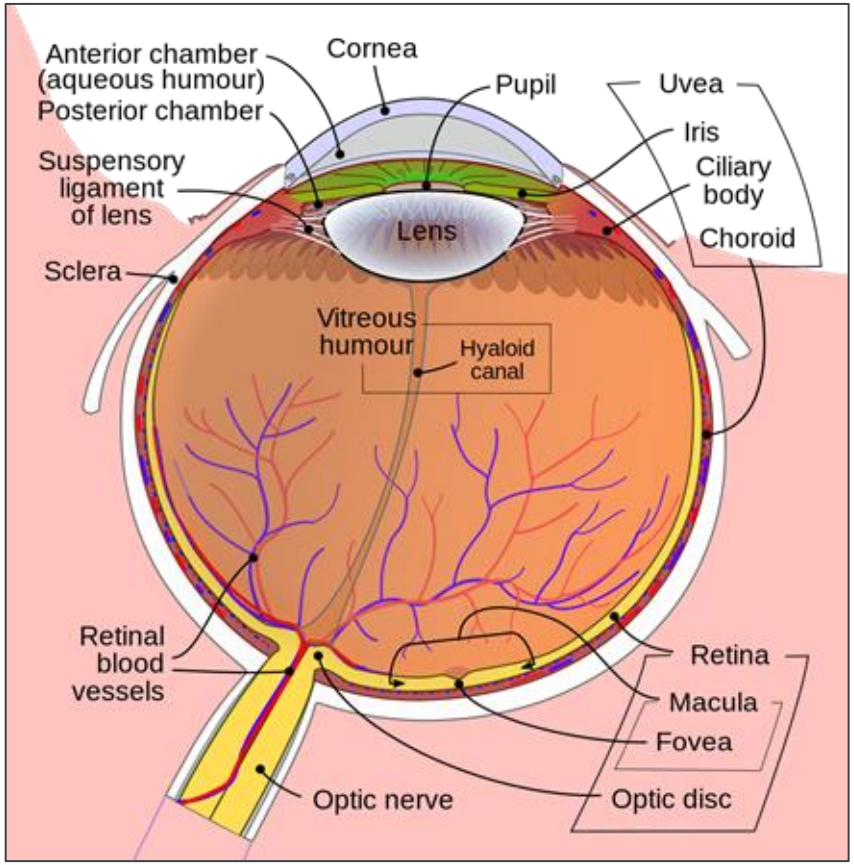
Data tensor:

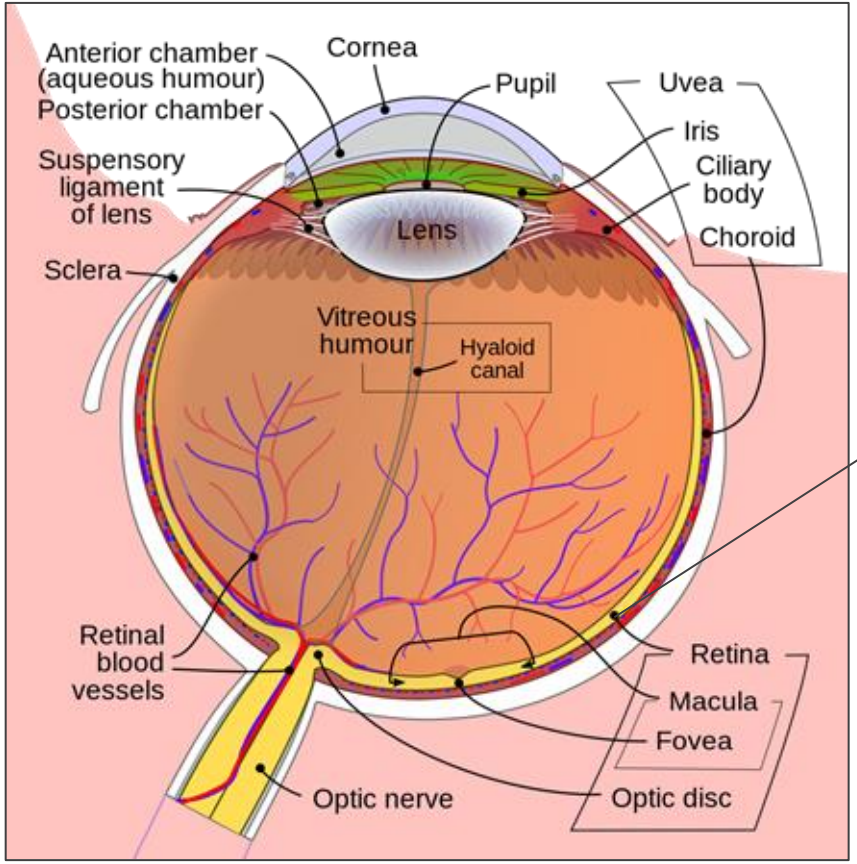
a multidimensional array that represents an input or an output

multi-channel

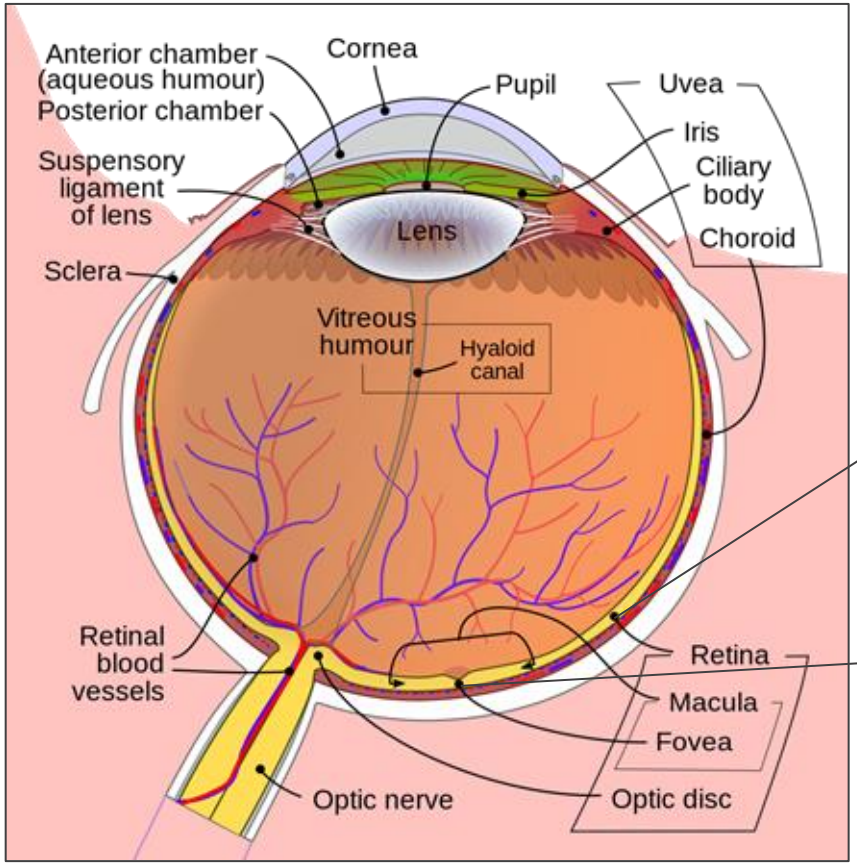
```
[[???, ???, ???, ..., ???, ???, ???],
 [???, ???, ???, ..., ???, ???, ???],
 [???, ???, ???, ..., ???, ???, ???],
  ...,
 [???, ???, ???, ..., ???, ???, ???],
 [???, ???, ???, ..., ???, ???, ???],
 [???, ???, ???, ..., ???, ???, ???]]
```


R
G
B


Anterior chamber
(aqueous humour)
Posterior chamber
Cornea
Pupil
Uvea
Iris
Ciliary
body
Choroid
Suspensory
ligament
of lens
Lens
Sclera
Vitreous
humour
Hyaloid
canal
Retinal
blood
vessels
Retina
Macula
Fovea
Optic nerve
Optic disc

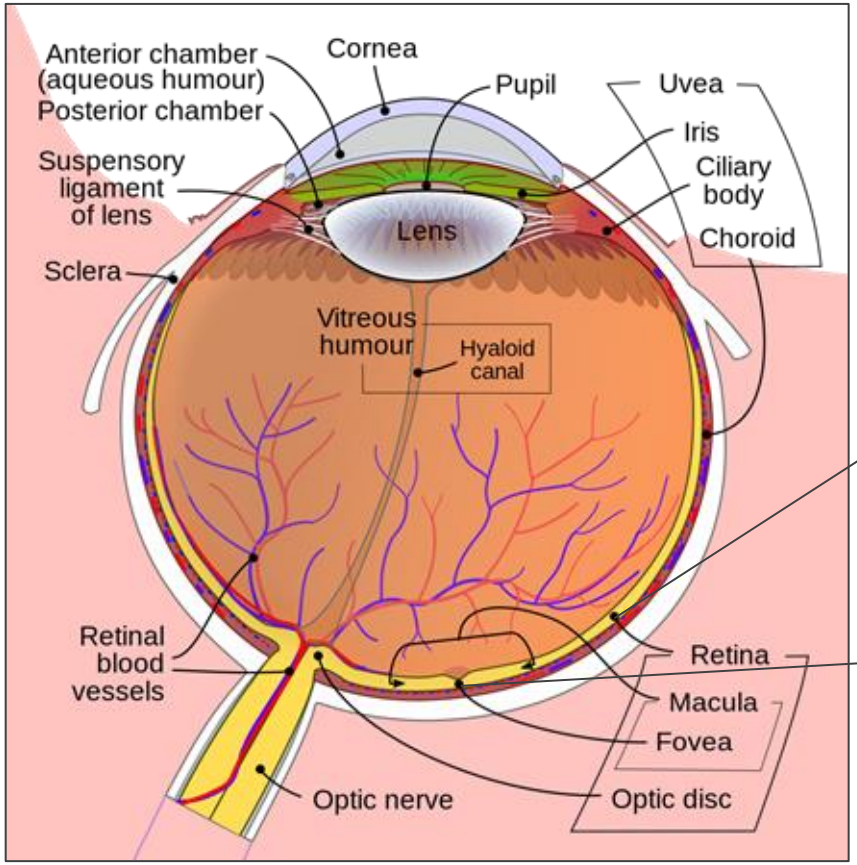


rod cells:
more sensitivity to light, but
no wavelength distinction



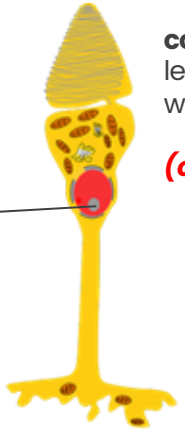
rod cells:
more sensitivity to light, but
no wavelength distinction

cone cells:
less sensitivity to light, but
with wavelength distinction



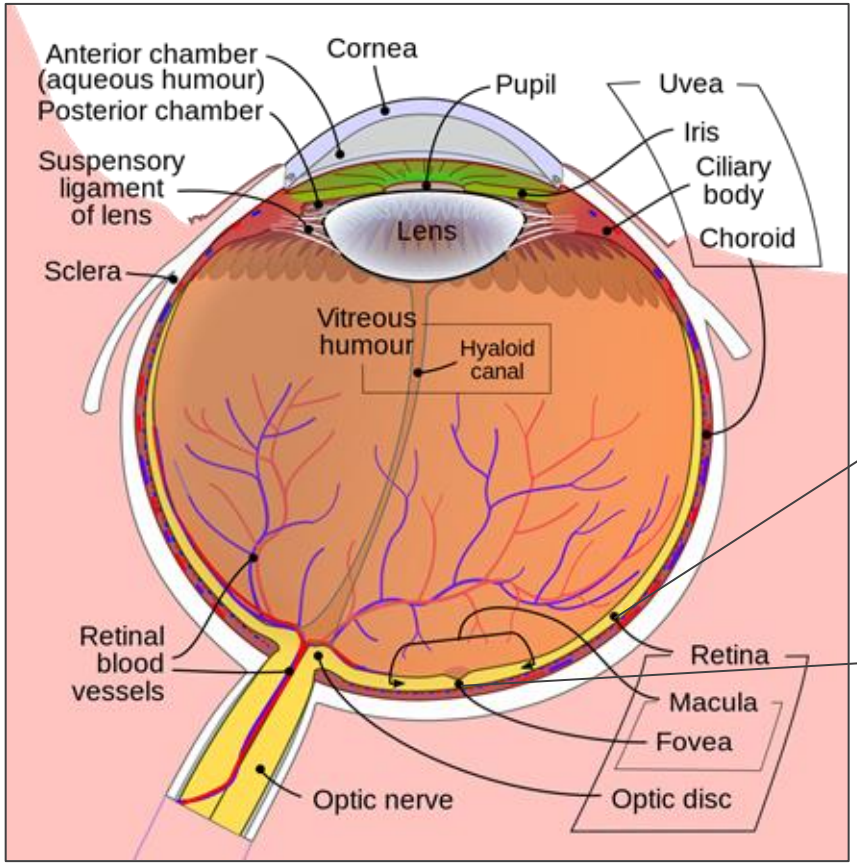
rod cells:
more sensitivity to light, but
no wavelength distinction

(night vision)



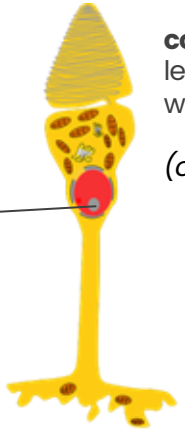
cone cells:
less sensitivity to light, but
with wavelength distinction

(color vision)



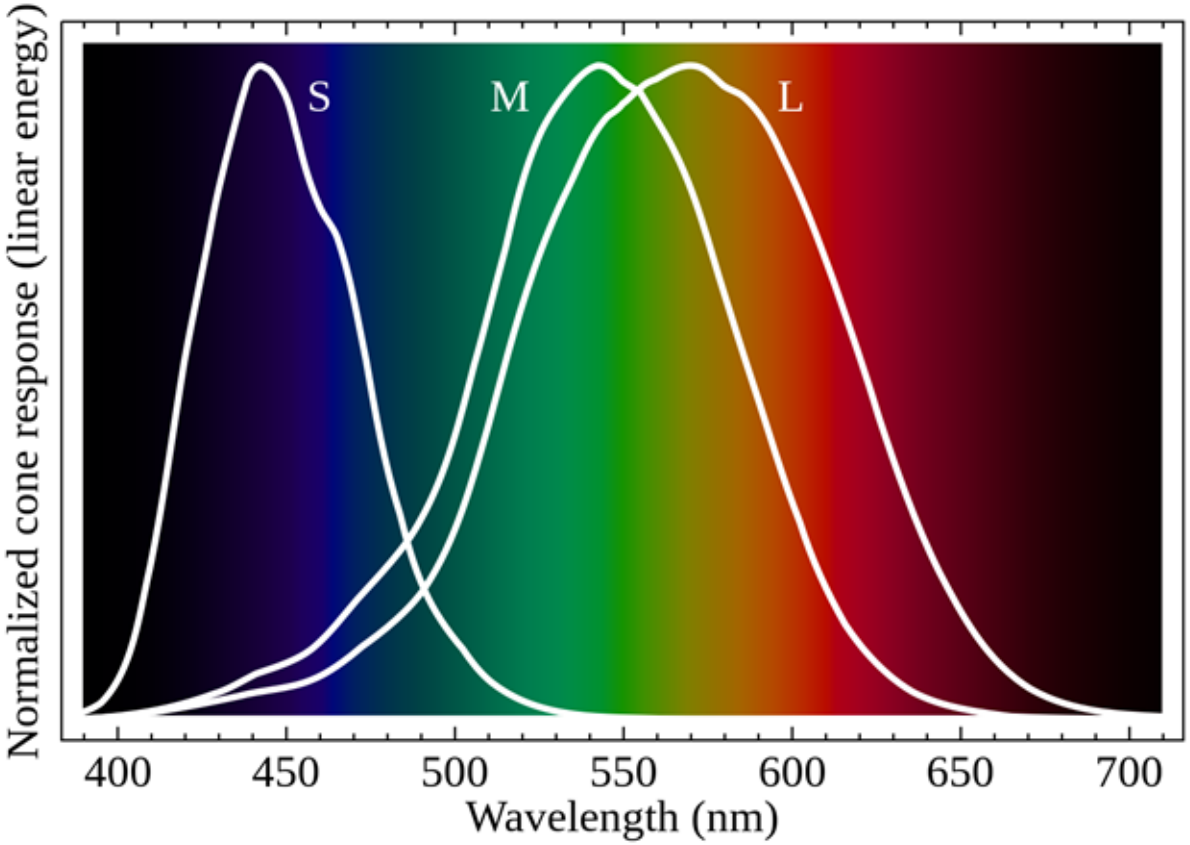
rod cells:
more sensitivity to light, but no wavelength distinction

(night vision)



cone cells:
less sensitivity to light, but with **wavelength distinction**

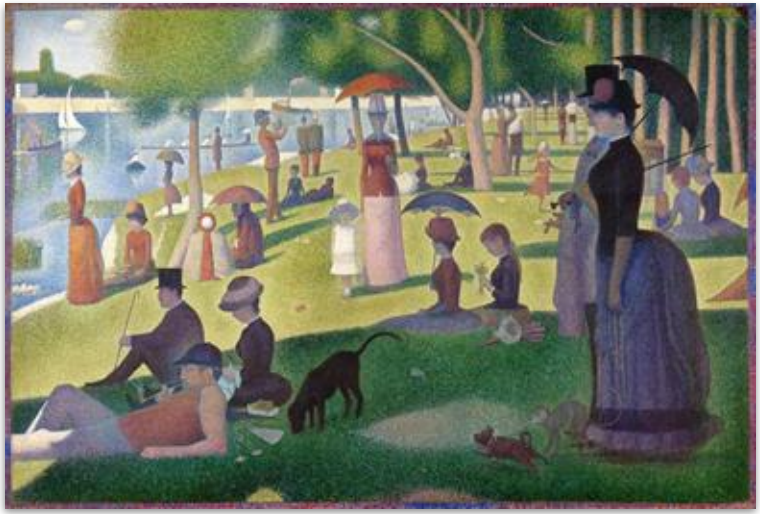
(color vision)


Normalized cone response (linear energy)
S
M
L
400
450
500
550
600
650
700
Wavelength (nm)

Optical mixing:

adjacent points from a discrete spectrum
create a perception of continuous spectrum

Impression, soleil levant
Claude Monet, 1872



Un dimanche après-midi à l'Île de la Grande Jatte
Georges Seurat, 1884-1886

Optical mixing:

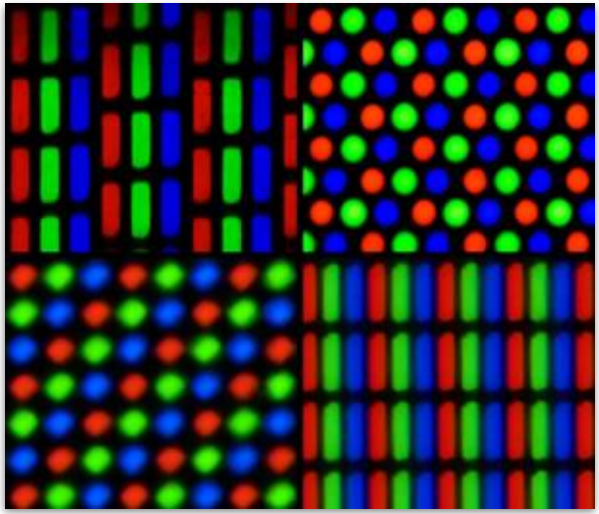
adjacent points from a discrete spectrum
create a perception of continuous spectrum

RGB LED

halftone printing

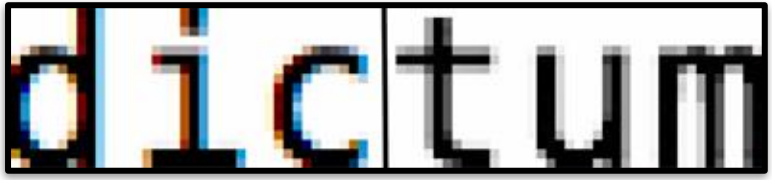
Optical mixing:

adjacent points from a discrete spectrum
create a perception of continuous spectrum



CRT and LCD pixel geometries

GIF image dithering

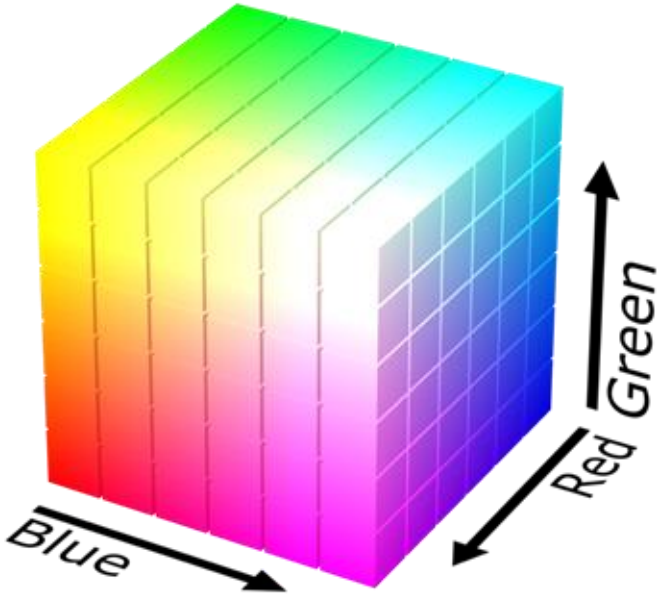


subpixel and pixel rendering

The RGB color model:

- **1 byte** that represents the intensity of **red**; *(0-255)*
- **1 byte** that represents the intensity of **green**; *(0-255)*
- **1 byte** that represents the intensity of **blue**; *(0-255)*
- approximately **16 million** combinations. *(256^3)*

The RGB color space



The RGB model limitations

The RGB model limitations

- Reducing or increasing one of the intensities does not simply change the wavelength of the color. *(hue)*

The RGB model limitations

- Reducing or increasing one of the intensities does not simply change the wavelength of the color. *(hue)*
- This also changes the average intensity... *(brightness)*

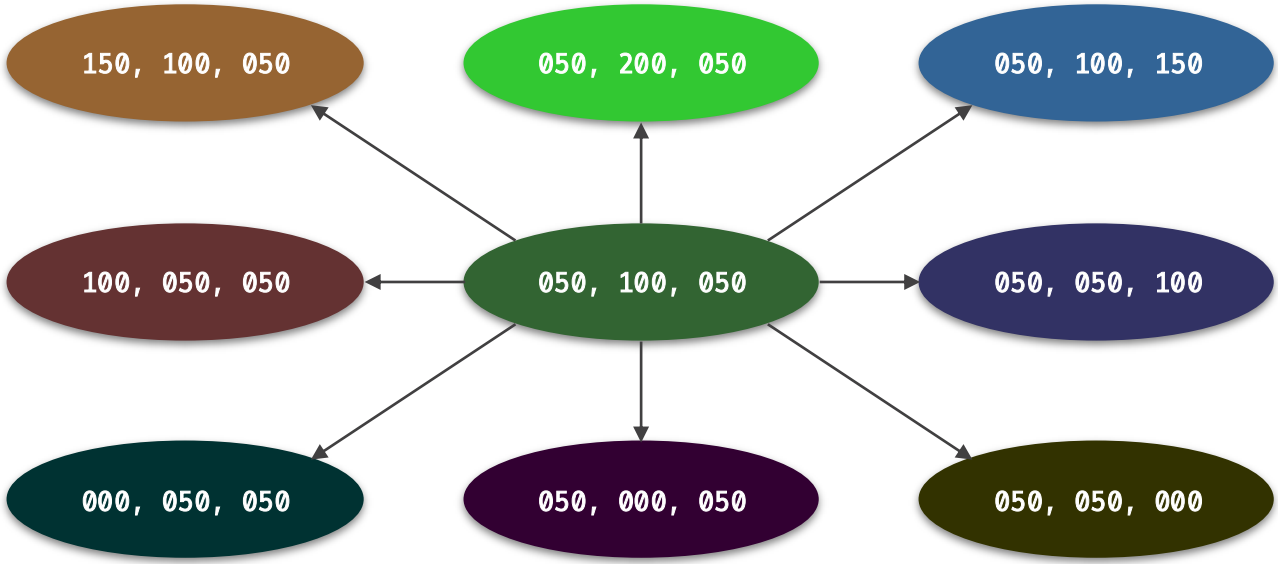
The RGB model limitations

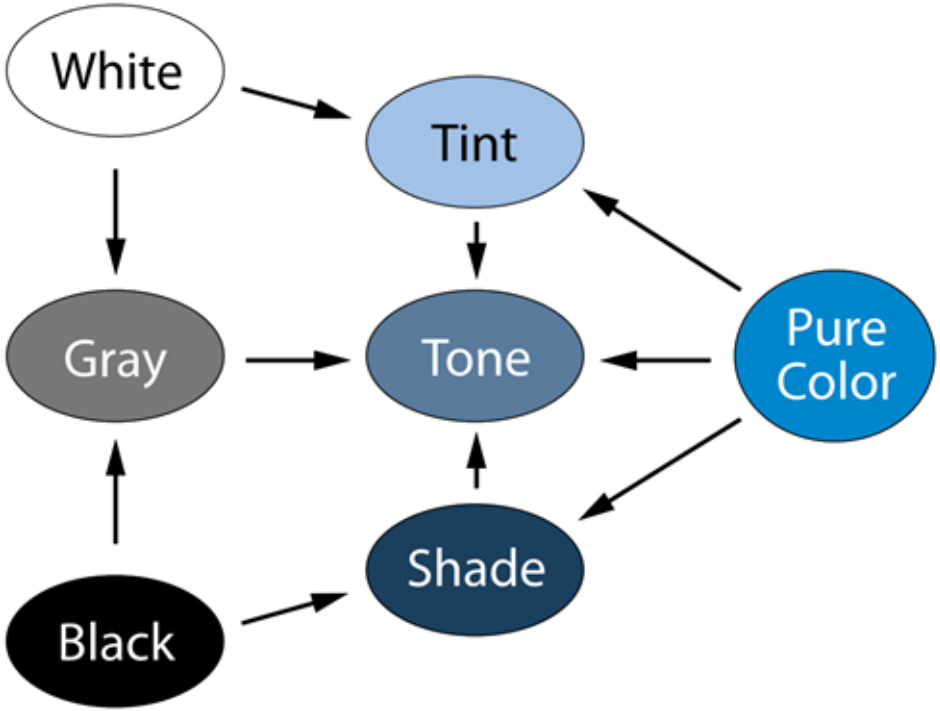
- Reducing or increasing one of the intensities does not simply change the wavelength of the color. *(hue)*
- This also changes the average intensity... *(brightness)*
- ...and the variation of the intensity. *(saturation)*

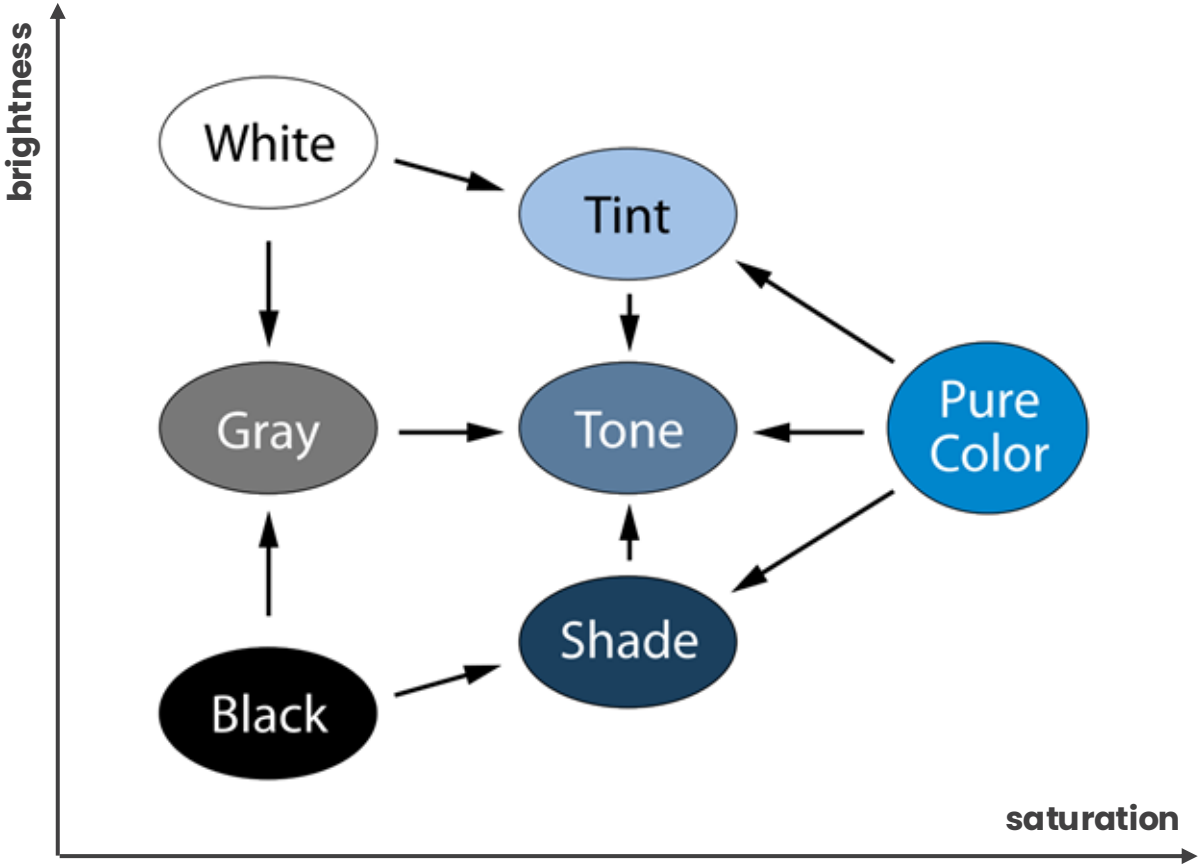
The RGB model limitations

- Reducing or increasing one of the intensities does not simply change the wavelength of the color. *(hue)*
- This also changes the average intensity... *(brightness)*
- ...and the variation of the intensity. *(saturation)*
- Depending on the goal, a vector distance is meaningless.

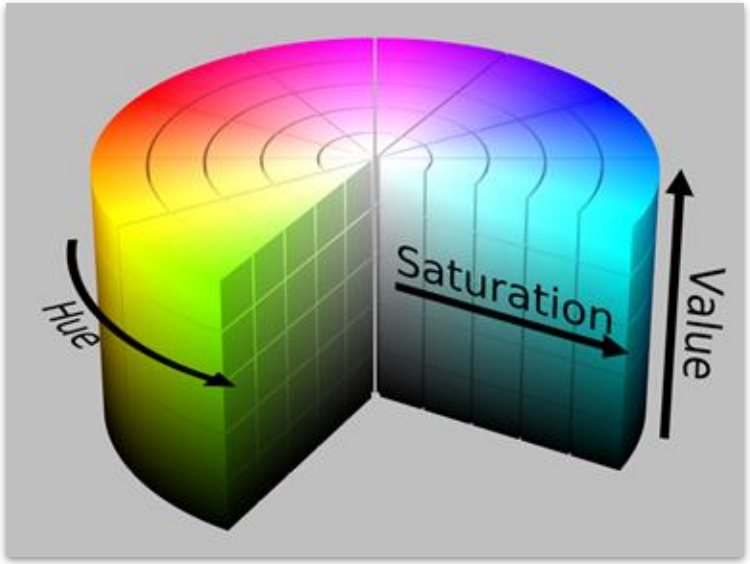
The RGB model limitations

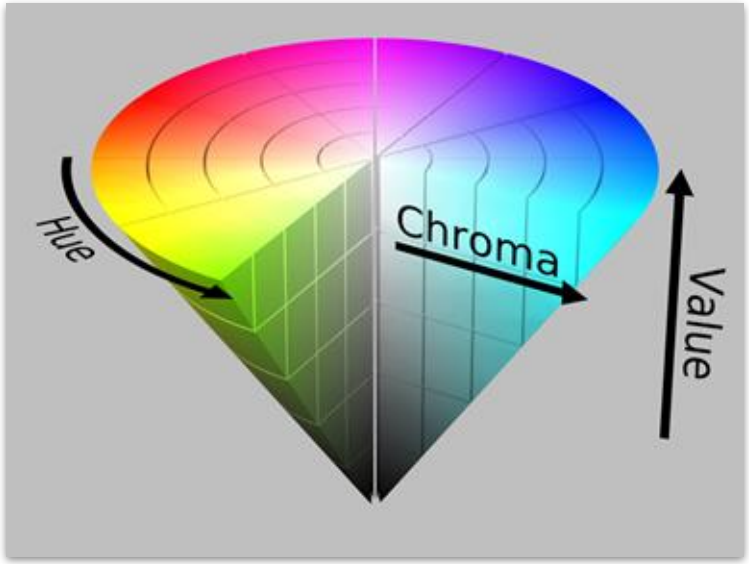



White
Tint
Gray
Tone
Pure Color
Shade
Black

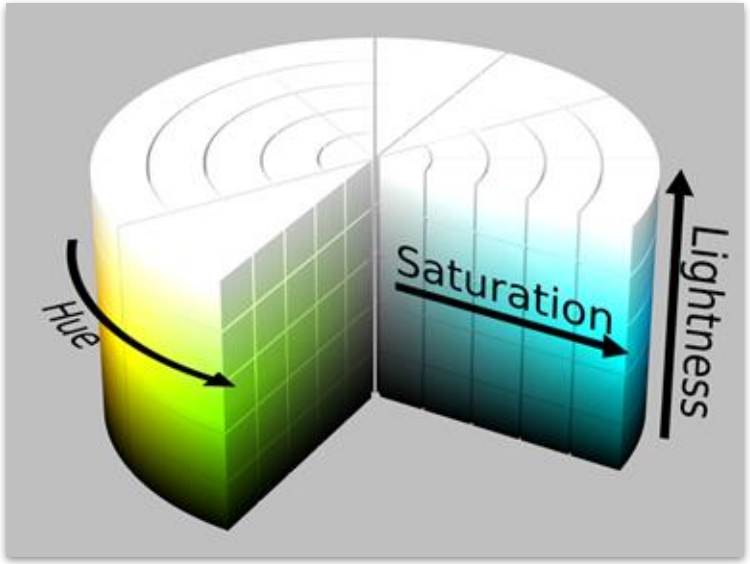

brightness
White
Tint
Gray
Tone
Pure Color
Shade
Black
saturation

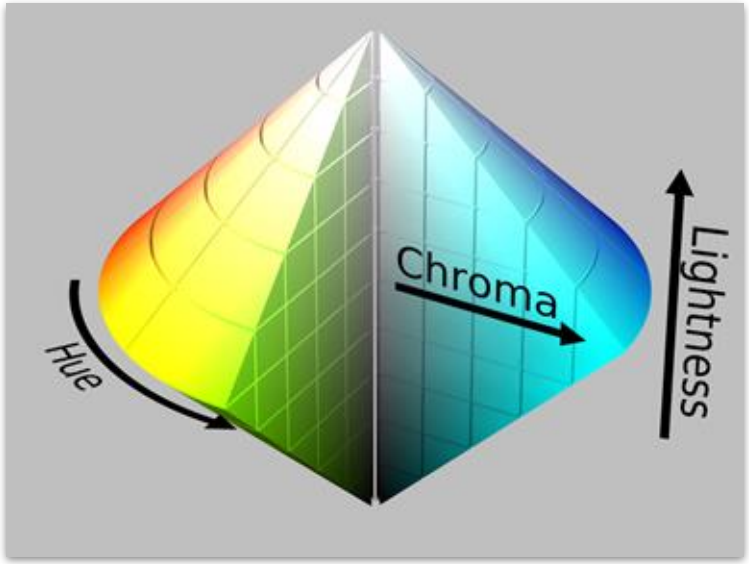
The HSV color space





The HSL color space

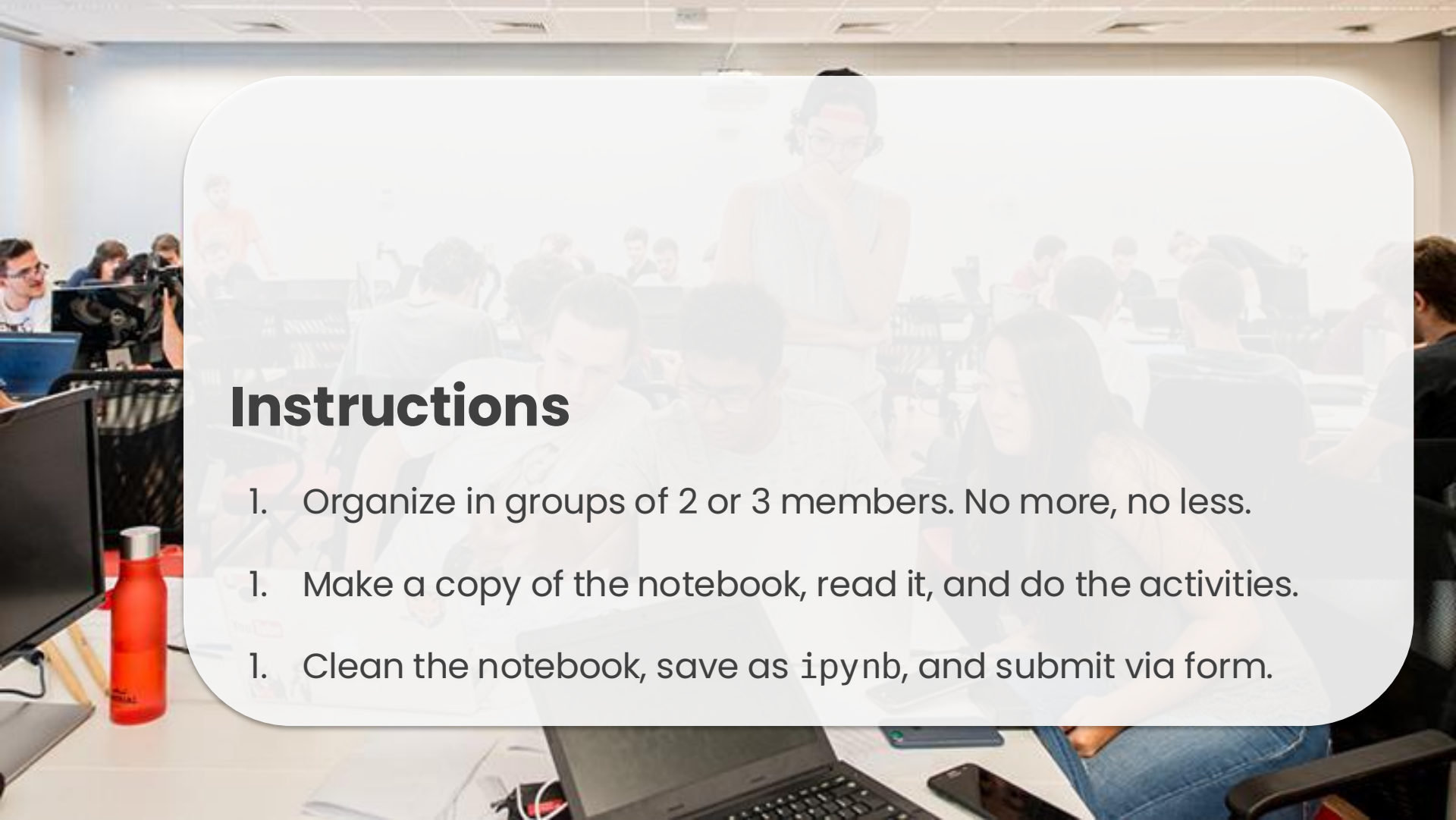




handout

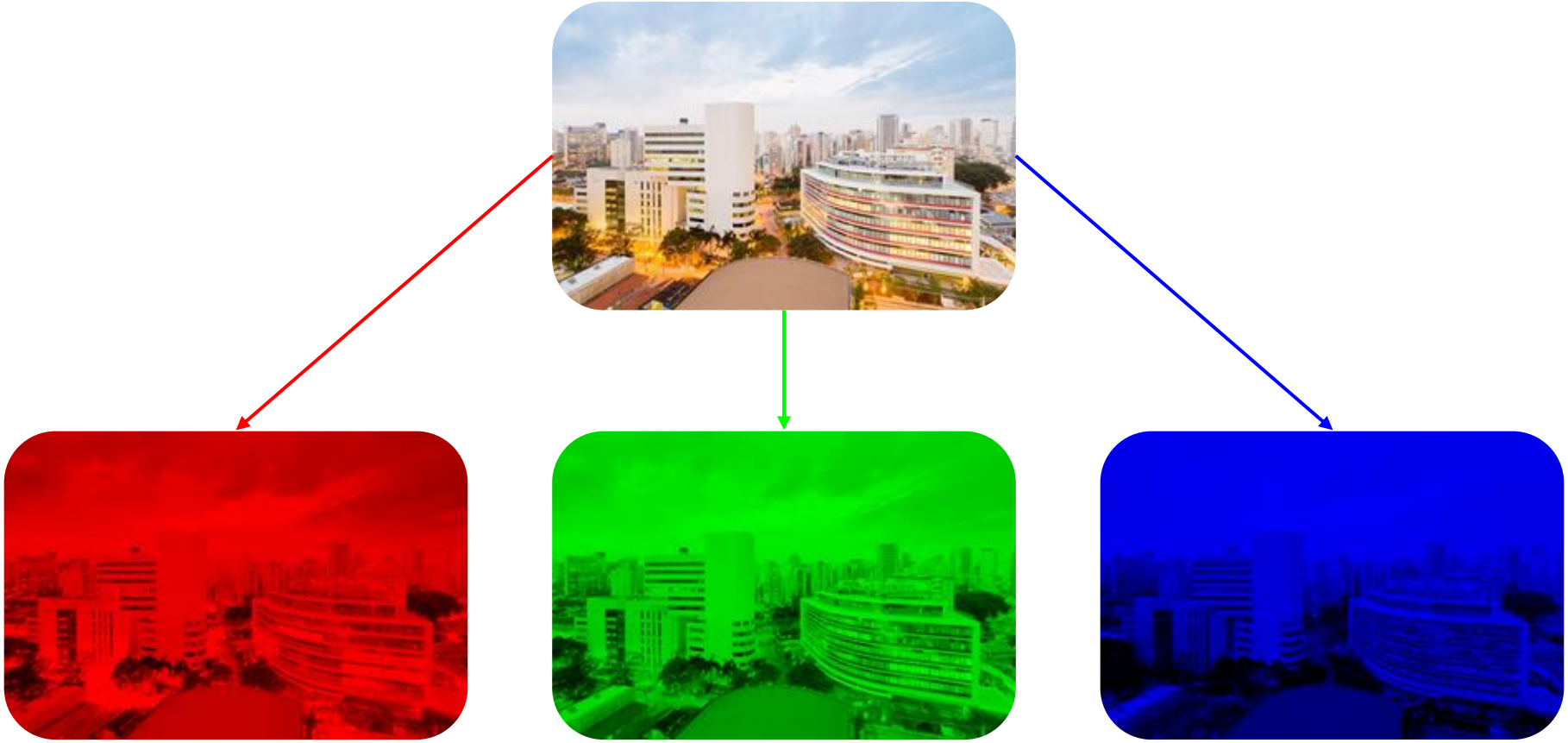
Toolkit

- **Language:** Python
- **Library:** OpenCV
- **Platform:** Google Colab



Instructions

1. Organize in groups of 2 or 3 members. No more, no less.
1. Make a copy of the notebook, read it, and do the activities.
1. Clean the notebook, save as `ipynb`, and submit via form.



Next class:

- gray level adjustment.

Credits

This material was based on the work of other professors, listed below.

- Fabio Miranda (fabiomiranda@insper.edu.br)
- Raul Ikeda (RaulIGS@insper.edu.br)
- Fabio Ayres (FabioJA@insper.edu.br)
- Igor Montagner (IgorSM1@insper.edu.br)
- Andrew Kurauchi (AndrewTNK@insper.edu.br)
- Luciano Silva (LucianoS4@insper.edu.br)
- Tiago Sanches (tiagoss4@insper.edu.br)

Well, except for the errors. Any errors you might find are probably my fault.

Images

https://www.insper.edu.br/campus/
https://en.wikipedia.org/wiki/RGB_color_model
https://cultfaction.com/2015/10/31/cult-movie-essentials-ringu-1998/
https://en.wikipedia.org/wiki/Fovea_centralis
https://en.wikipedia.org/wiki/Rod_cell
https://en.wikipedia.org/wiki/Cone_cell
https://en.wikipedia.org/wiki/Impression,_Sunrise
https://en.wikipedia.org/wiki/A_Sunday_Afternoon_on_the_Island_of_La_Grande_Jatte
https://en.wikipedia.org/wiki/Light-emitting_diode
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https://en.wikipedia.org/wiki/Pixel_geometry
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