CS180/280A Discussion #1

Konpat

Credits:
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Welcome!!

GSIs

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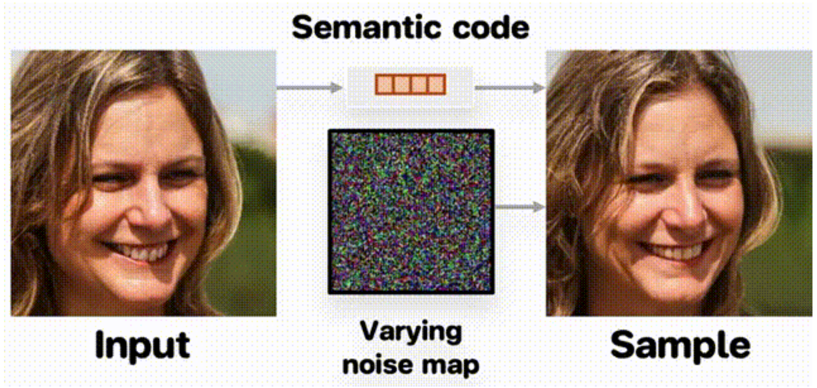
Me: **Konpat** Preechakul 🖖

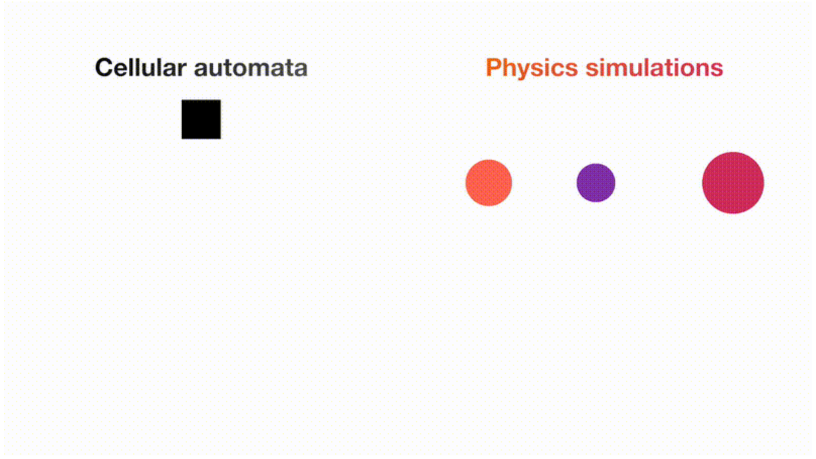
"Learning abstractions from pixels"

Diffusion models & Representation learning



Scene understanding

Machine learning

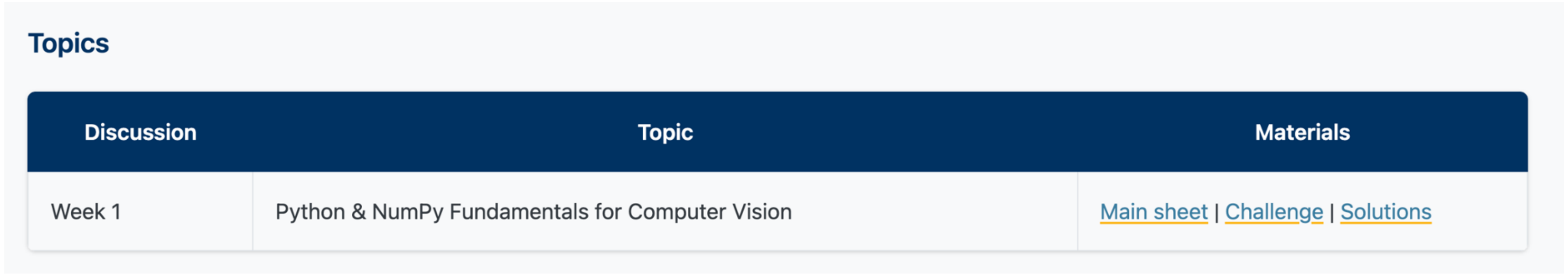


Reminders

Proj1 due Thurs **9/12** 11:59pm

OH dates are released!

Worksheets online:



Topics

Discussion	Topic	Materials
Week 1	Python & NumPy Fundamentals for Computer Vision	Main sheet | Challenge | Solutions

Discussions this year!

- **Practical practice** (for Projs) + **Conceptual understanding** (for exams)
- **Collaborative**! Move to be near someone! :)
- **Minimal laptop.** We want you to go through with your hand!
  - For future sessions if you want to use laptop, please sit in the back.
- Numbered problems are in scope for exams, bonus questions are intended to be *hard* for people who want to try them
- **Note:** these are new this year! (rough □)
- After next week will circulate a feedback form

What are your questions?

Agenda

- Short lectures (10 mins)
- Problems (10 mins)
- A bit more lectures (10 mins)
- A bit more problems (10 mins)

This discussion: Visual world 🤝 Computers

“Intro to Computer Vision and Computational Photography”

→

???

This discussion: Visual world 🤝 Computers

We need to learn how to **1) input, 2) store, and 3) manipulate 4) output images!**

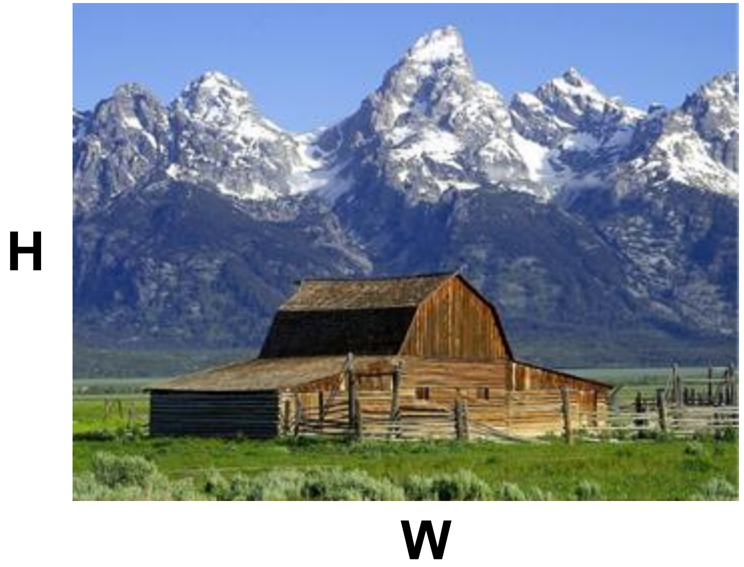
$\longrightarrow$

Storing data?

Visualizing?

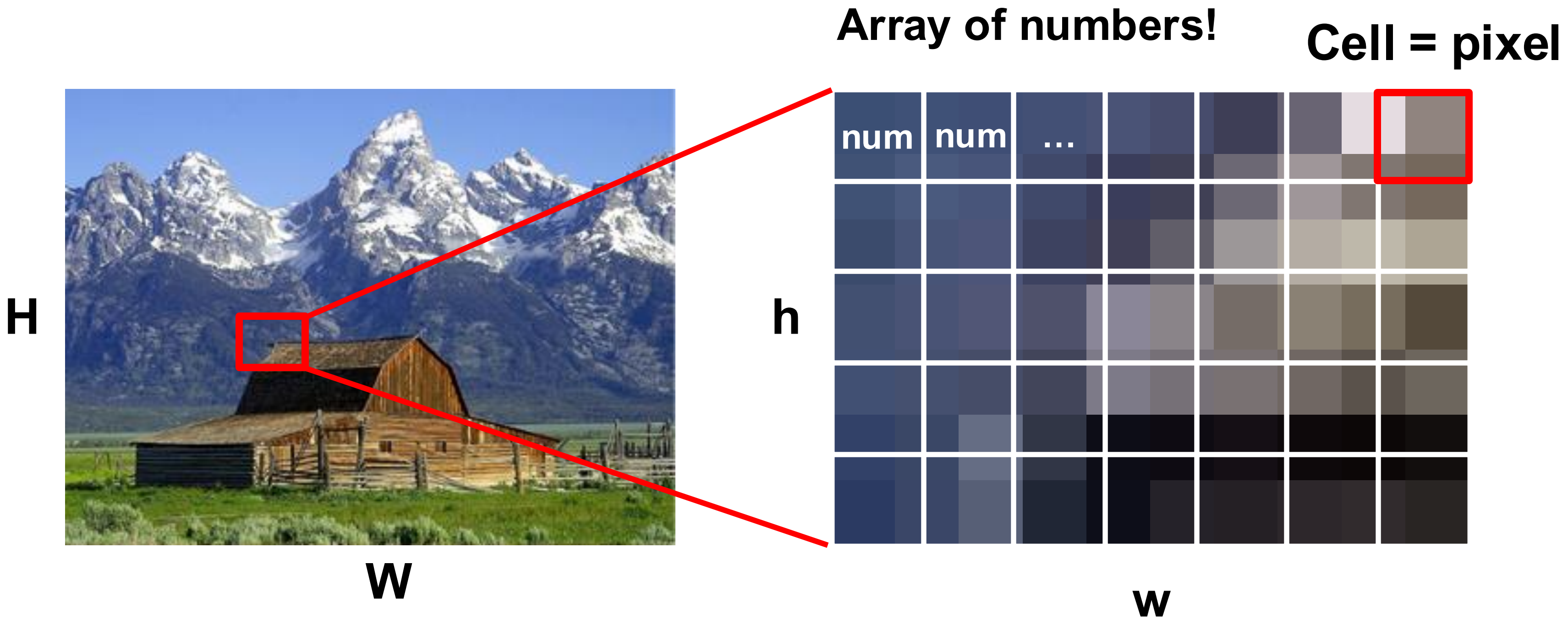
What data structure are images?

An image is an **array** of pixels!

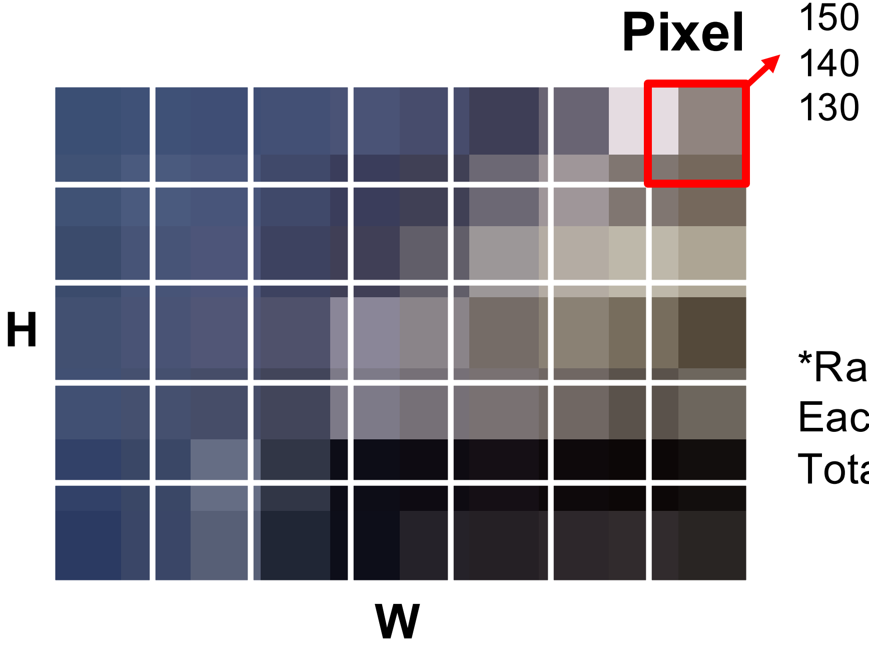


What data structure are images?

An image is an **array** of pixels!

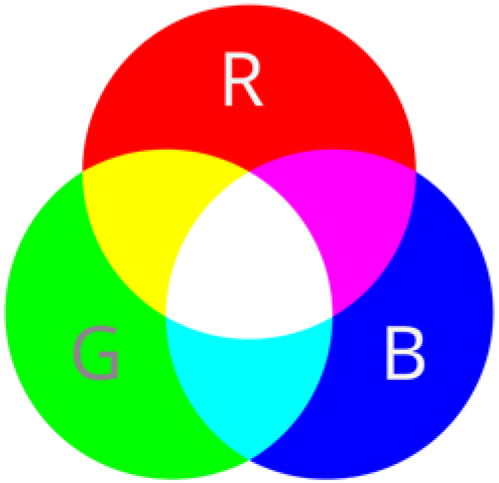


What is a pixel?



COLOR!

3 channels: red, green, blue



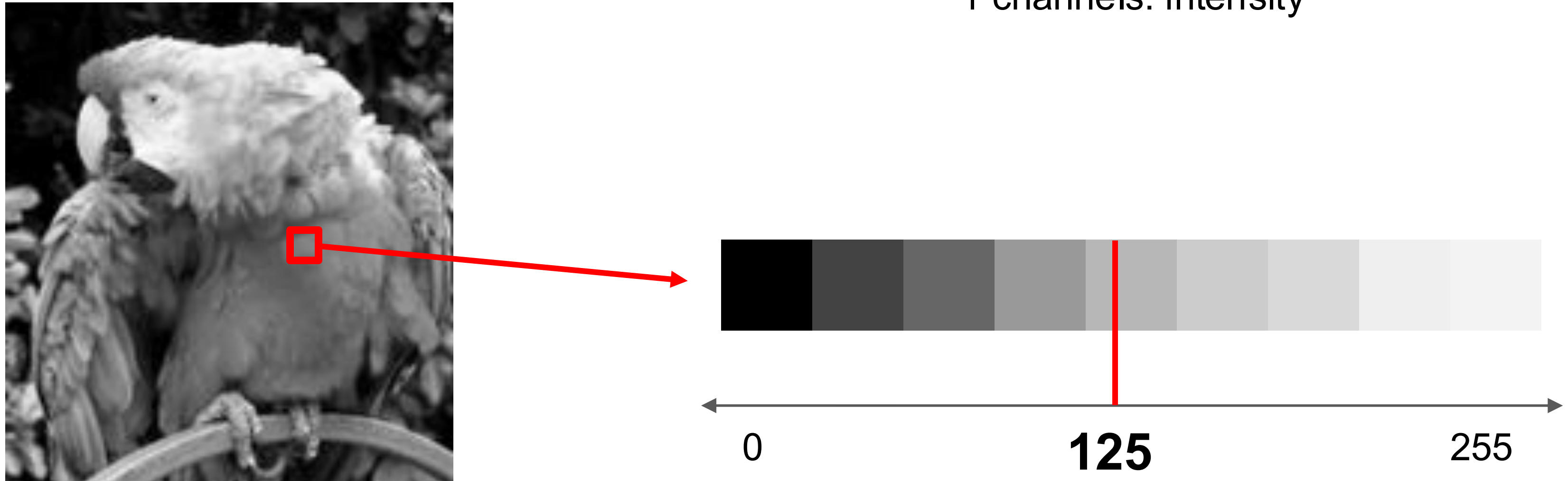
*Range (0 – 255)
Each color 8 bits
Total **24-bit color**

*RGB vs. BGR conventions

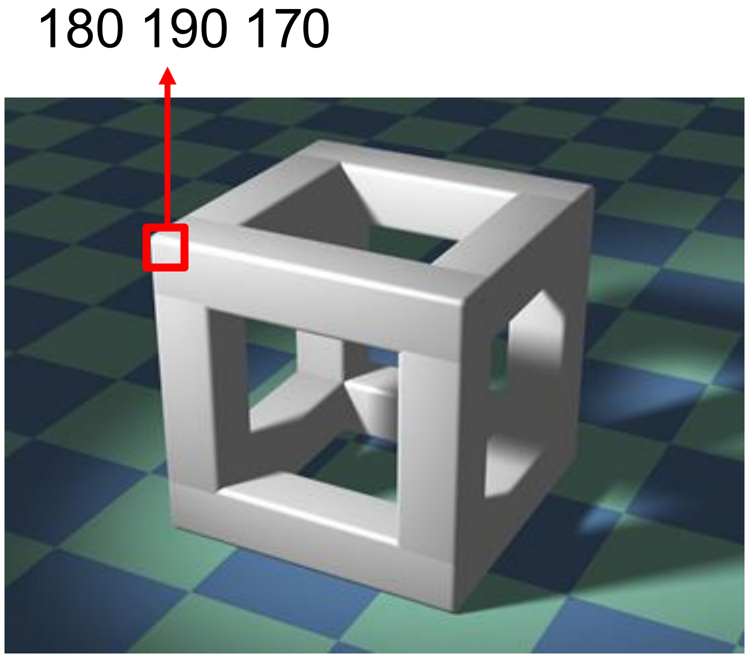
Pixel is not always 3 numbers!

Grayscale!

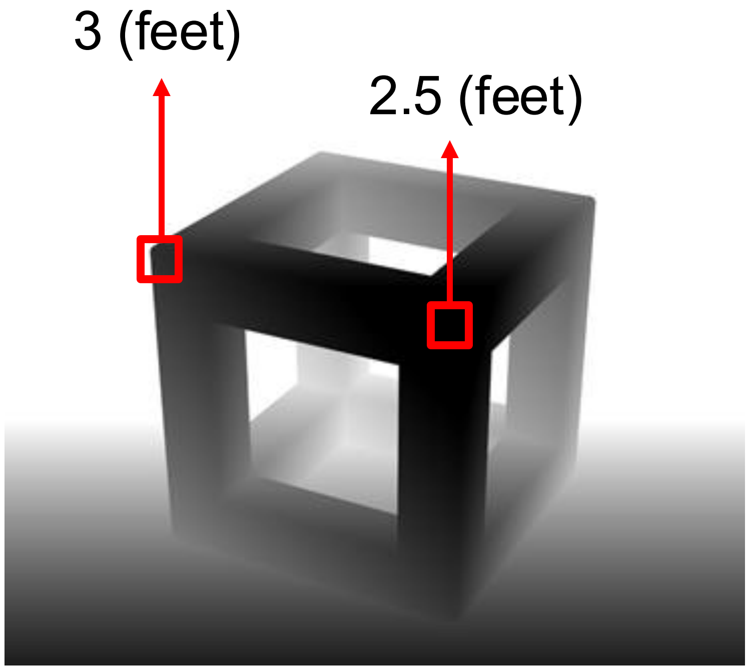
1 channels: intensity



Pixel can be something else!



Depth!



How do we get these things into python anyway…

Notebook demo

# we load with **cv2.imread(filename)**

# we visualize with matplotlib’s **plt.imshow(filename)**

# then we probe like, what is the type / shape of this image

# lol it is **an array!**

# what are the values, etc.

# zoom in, zoom out, get the colors right

Inspecting images

2 primary formats:

- uint8, 0->255 scaling
- float, 0->1.0 scaling

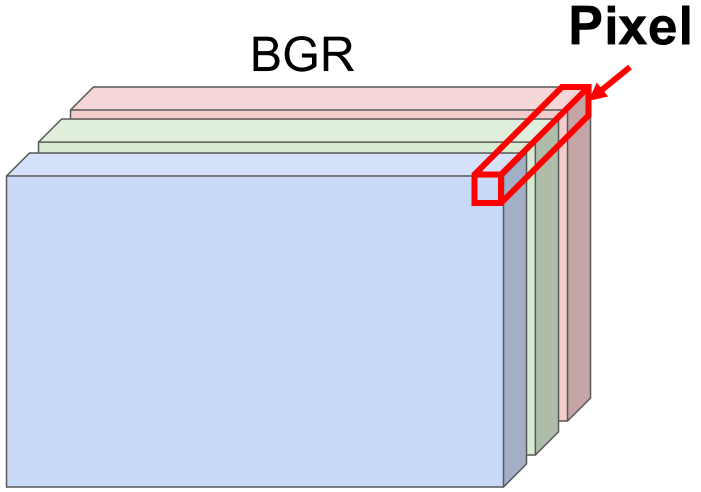
Be careful converting!

```
>>> img = cv2.imread(“img.jpg”)

>>> print(img.shape) # shape (1080, 1920, 3)

>>> print(img.dtype) # np.uint8

>>> print(img.min(), img.max()) # 0 255
```

Pixel layout in an array

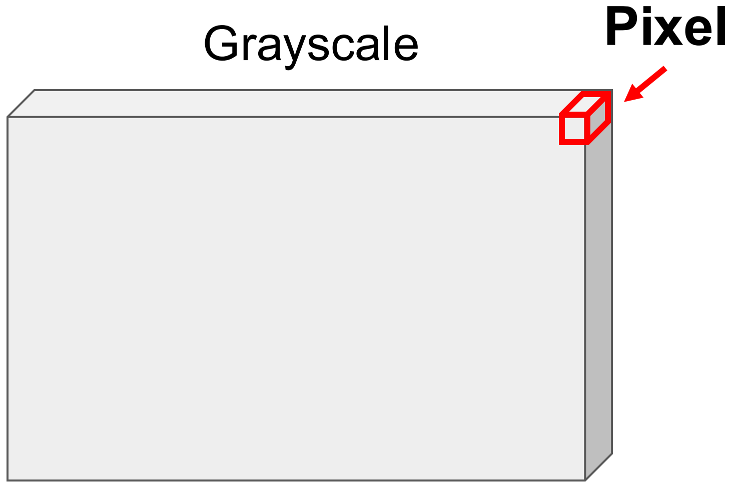
```
>>> img = cv2.imread("img.jpg") # shape (1080, 1920, 3)
```

Pixels stored along ***channels***.



`(H,W,C)` `C=3` "channel-last"

… `or` `(C,H,W)` "channel-first"



`(H,W)` or `(H,W,1)`

Singleton dim.

*BGR is a bit hard to visualize actually…

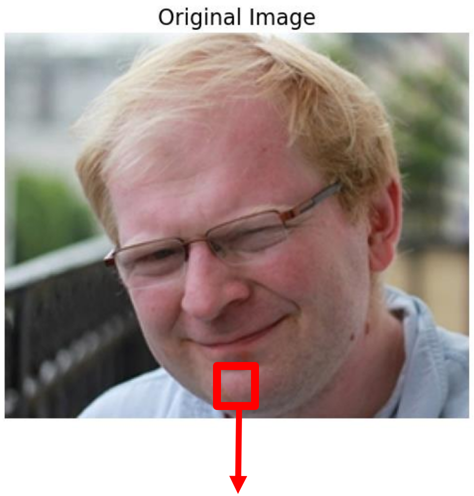
Good news: many image operations are just array operations!

NumPy

So fast, so easy 😉

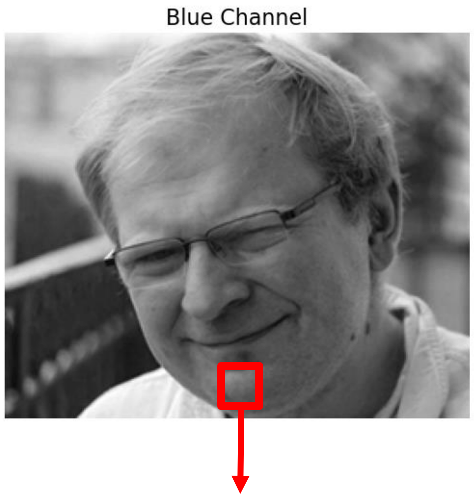
Let’s start: Color channel manipulation (1.3 Slicing)

```
>>> img
```



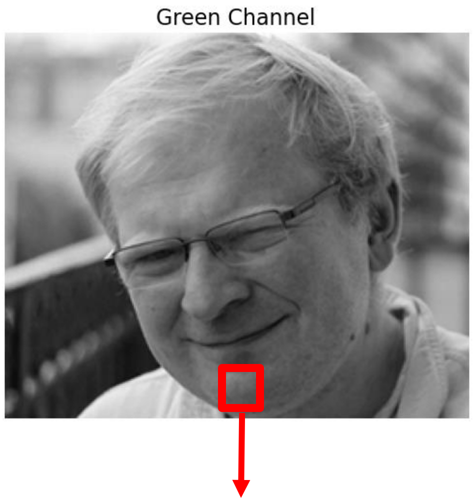
150
101
105

```
>>> img[...,0]
```



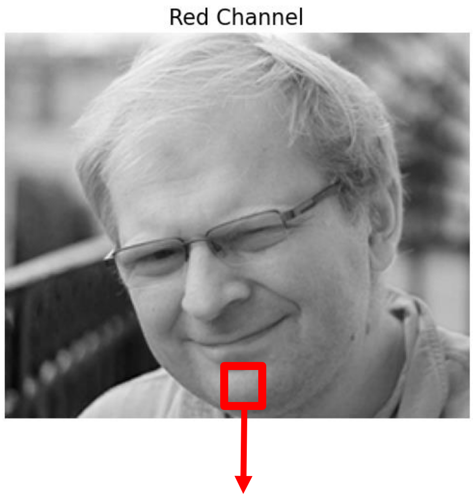
105

```
>>> img[...,1]
```



101

```
>>> img[...,2]
```

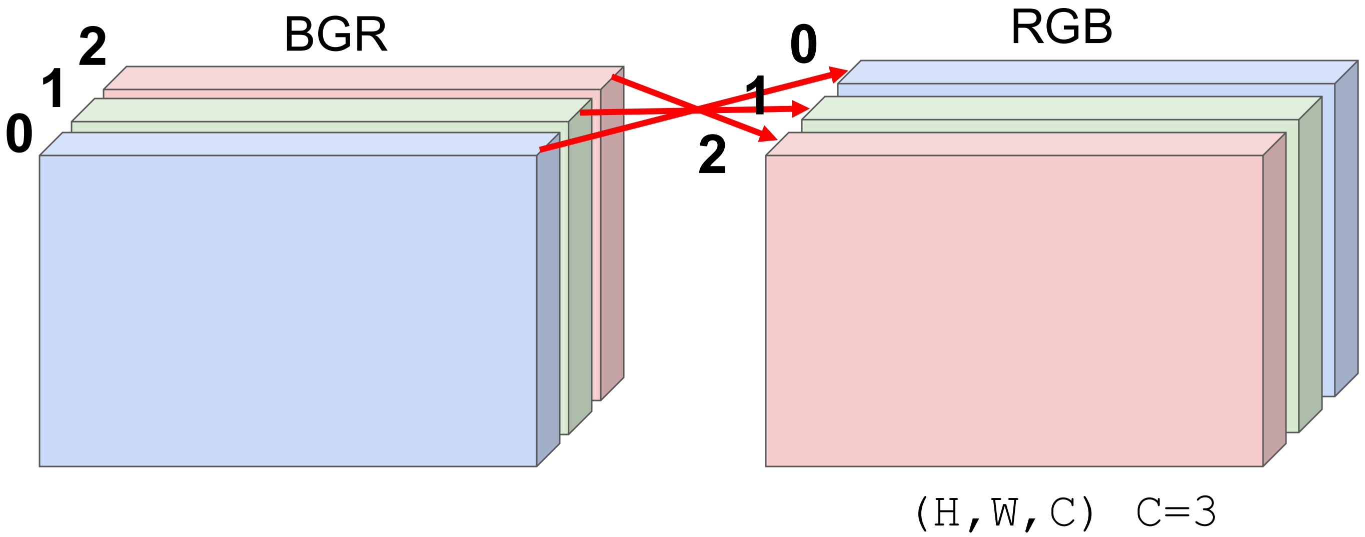


150

*Reminds of Proj 1!

BGR => RGB (1.3 Slicing)

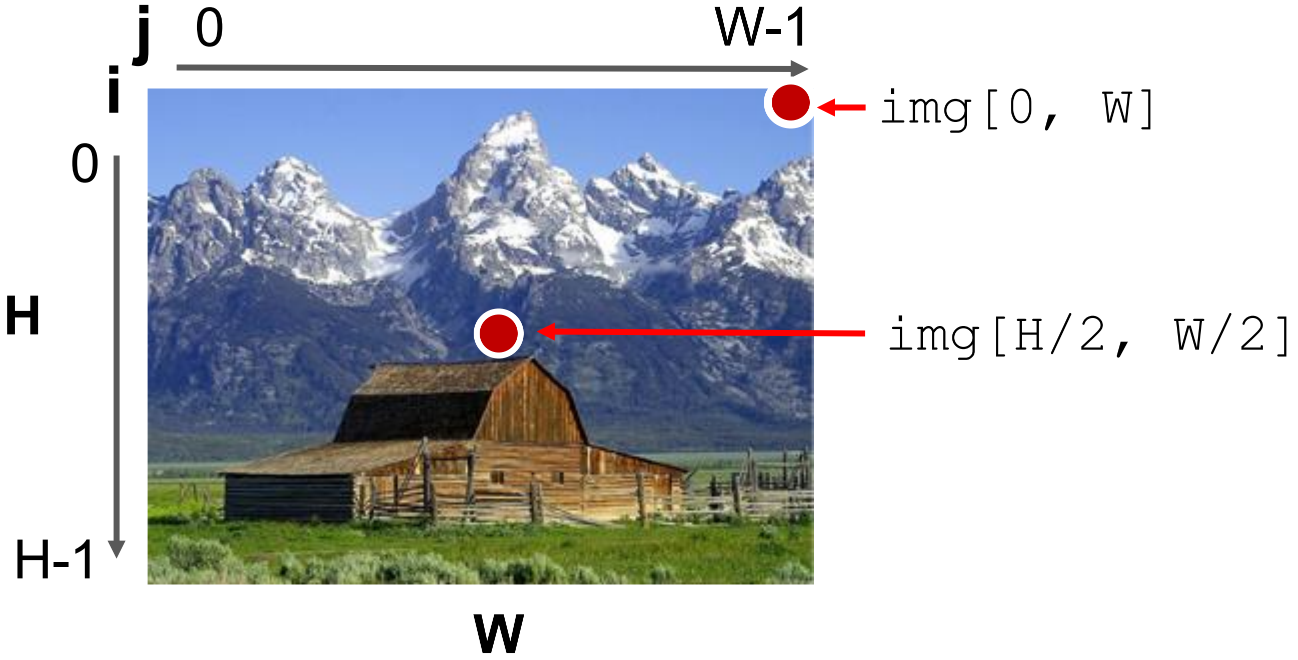
```
>>> img = img[:, :, [2,1,0]]
```



*Easier to plot. Show on notebook

Indexing conventions (1.3 Slicing)

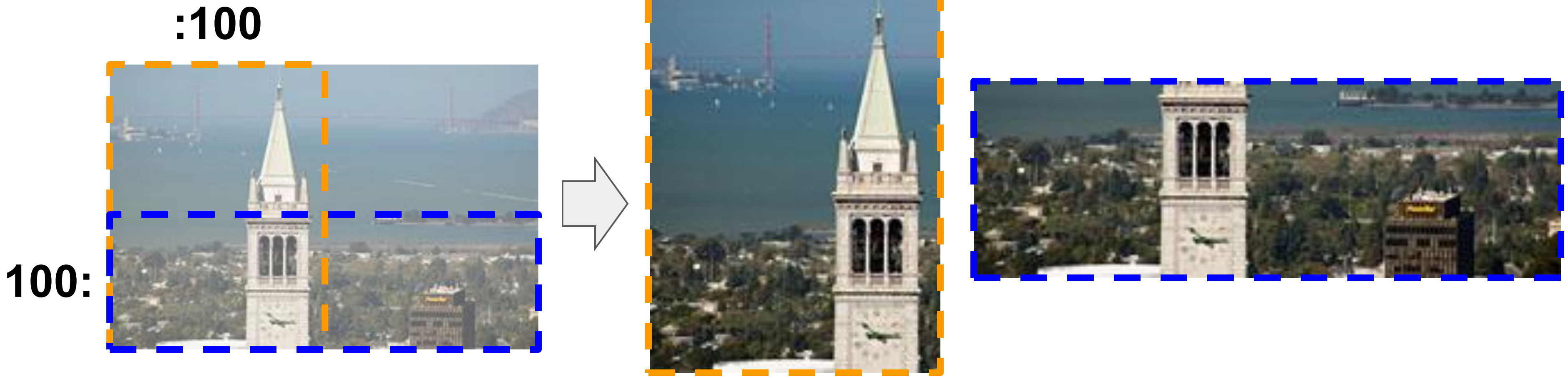
Index into arrays like i,j in a matrix, **not like** x,y in a coordinate plane!



: (colon)

Cropping images (1.3 Slicing)

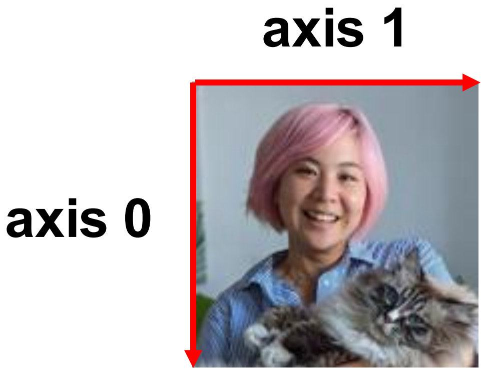
```
>>> left_half = img[:, :100, :]

>>> bottom_half = img[100:]
```

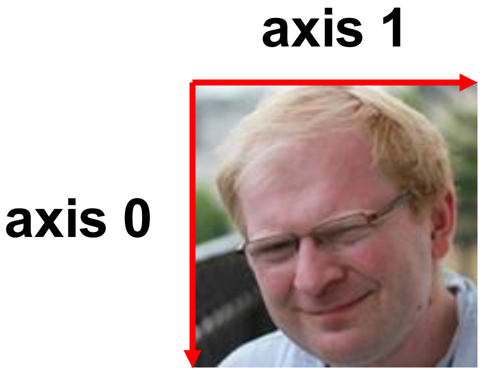


*Let me show you guys

Joining images (1.2 Stack & Concat)

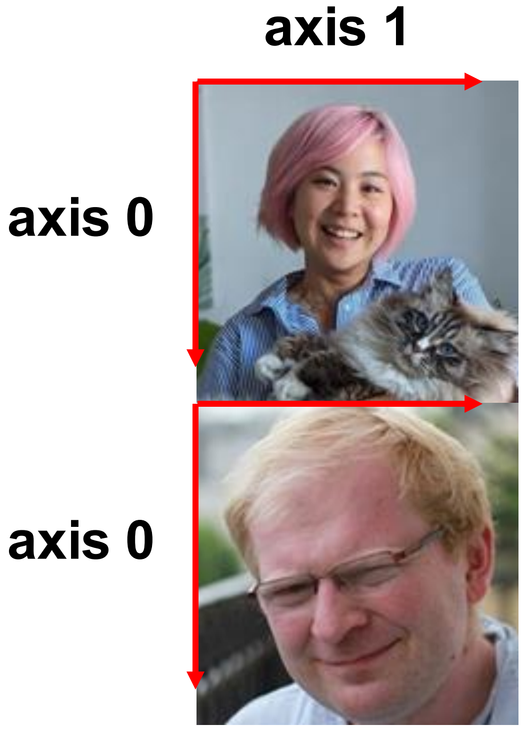
```
>>> vertical = np.concatenate([angjoo,alyosha],axis=0)
```



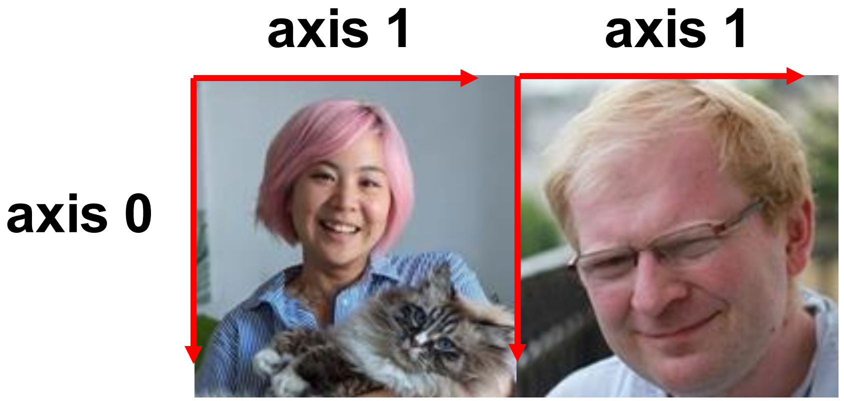


Joining images (1.2 Stack & Concat)

`np.concatenate([angjoo,alyosha],axis=0)`



`np.concatenate([angjoo,alyosha],axis=1)`



*Let me show you guys.

What are videos? (1.2 Stack & Concat)

```
>>> video = np.stack(frames, axis=0)
```

Videos are just arrays of *batches* of images!

`video`

`(T,H,W,C)`

`video[0]` `video[5]` `video[11]` `video[15]`

`(H,W,C)`

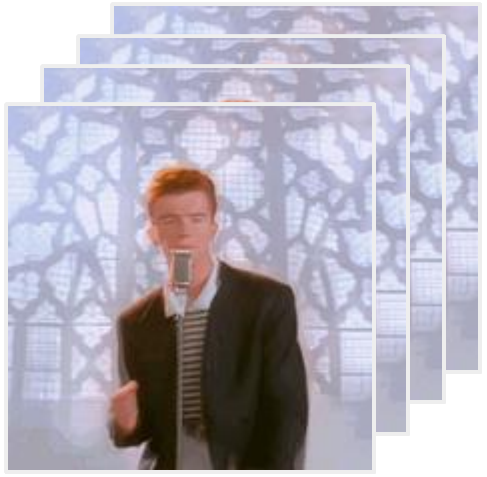
What are videos? (1.2 Stack & Concat)

```
>>> video = np.stack(frames, axis=0)
```

Videos are just arrays of *batches* of images!

Video being played

`(T,H,W,C)`



Actual video "Cube"

`(T,H,W,C)`

NumPy basics: do **Problems 1.1-1.8 (5 mins)** with the people around you!

Quick refresher on the following:

- **np.array([1, 2, 3])**
- **np.full(shape , value)**
- **array.astype(type)**
- **type: np.uint8, np.float32, np.float64**
- **array[i, j], array[a : b]**
- **np.concatenate([a ,b], axis=?)**
- **np.stack([a, b], axis=?)**

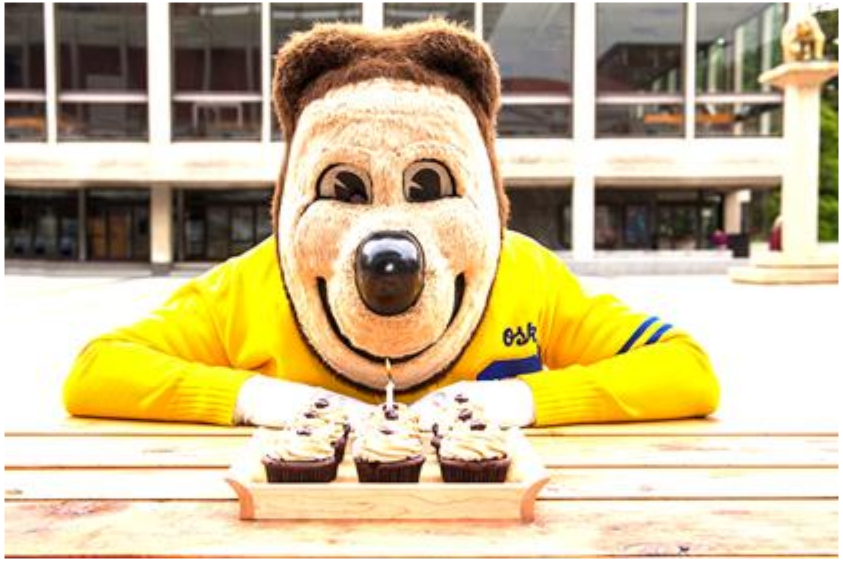
(Then we will go over quickly)

Pixel operations: Do **Problems 2.1-2.5 & 2.9 (5 mins)**

(Then we will go over quickly).

What happens when shapes don't match? (3)

```
>>> img = cv2.imread("img.jpg") # shape (1080, 1920, 3)

>>> brighter_img = img + np.array([100,100,100]) # shape (1080,1920,3) + (3,) ??
```

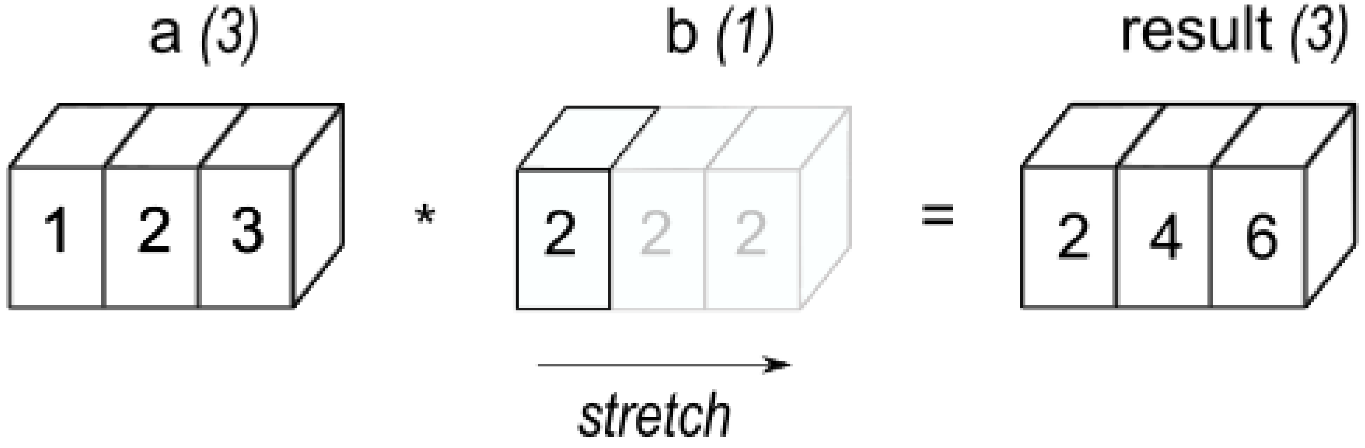


*Let me show you.

*Overflow

Broadcasting: automatically *repeat* elements to match!

```
>>> a = np.array([1, 2, 3])          # shape (3,)
>>> b = np.array(2)                  # shape ()!
>>> print( a * b )                   # [2.0,4.0,6.0] shape (3,)
```



Broadcasting

Rule for figuring out behavior:

1. **Line up** array shapes starting from the **right**
2. **For each axis:**
    a. If shapes match, continue to the left
    b. If shapes don’t match and one is 1, stretch its values to fit the larger
    c. If shapes don’t match and *neither* are 1, throw an error

$$\begin{array}{l}A = (2, 3)\\ B = (2, 1, 1)\end{array} \rightarrow \begin{array}{l}A = (2, 3)\\ B = (2, 1, 3)\end{array} \rightarrow \begin{array}{l}A = (2, 3)\\ B = (2, 2, 3)\end{array} \rightarrow \begin{array}{l}A = (1, 2, 3)\\ B = (2, 2, 3)\end{array} \rightarrow \begin{array}{l}A = (2, 2, 3)\\ B = (2, 2, 3)\end{array}$$

Broadcast: Do **Problems 3 (5 mins)**

Rule for figuring out behavior:

1. **Line up** array shapes starting from the **right**
2. **For each axis:**
    a. If shapes match, continue to the left
    b. If shapes don’t match and one is 1, stretch its values to fit the larger
    c. If shapes don’t match and *neither* are 1, throw an error

```
np.arange(3) =>          [0, 1, 2]
.reshape(3, 1) =>        [[0], [1], [2]]
```

Vectorization (4)

“Vectorization” means writing things with native NumPy operations rather than for loops

Much faster when possible!

Native C (low overhead) vs Python (high overhead)

SLOW

```
for i in range(H):
    for j in range(W):
        out[i,j,:] = (a[i,j] + b[i,j])/2.0
```

Fast `(a + b)/2.0`

*Let me show you

Vectorization: do **Problems 4!**

“Vectorization” means writing things with native NumPy operations rather than for loops

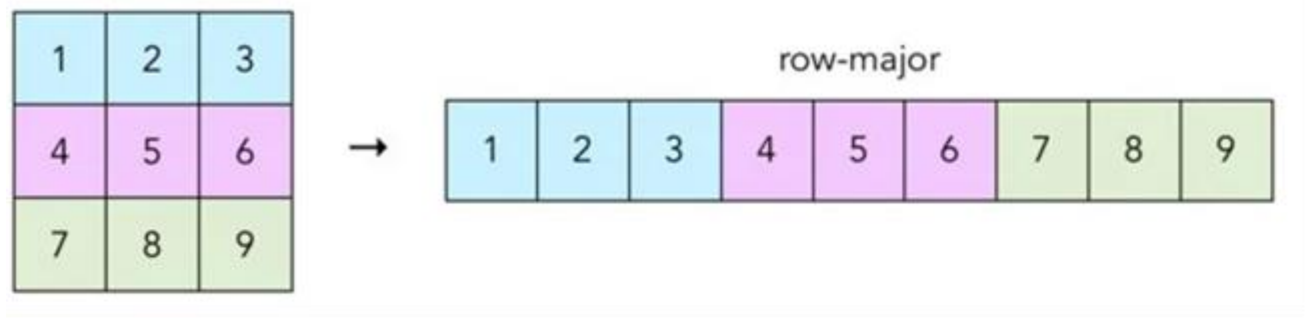
np.**mean**(…)

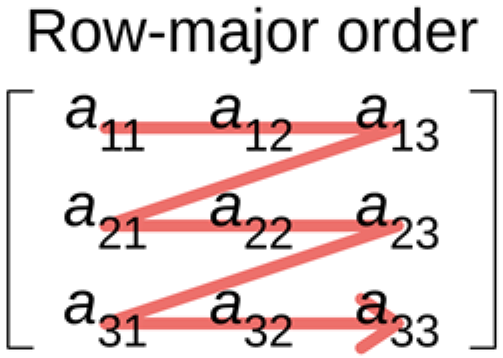
np.**sum**(…)

Manipulating shapes (5)

Many times we want to shuffle the order of axes or combine them.

Remember arrays are *row-major!*



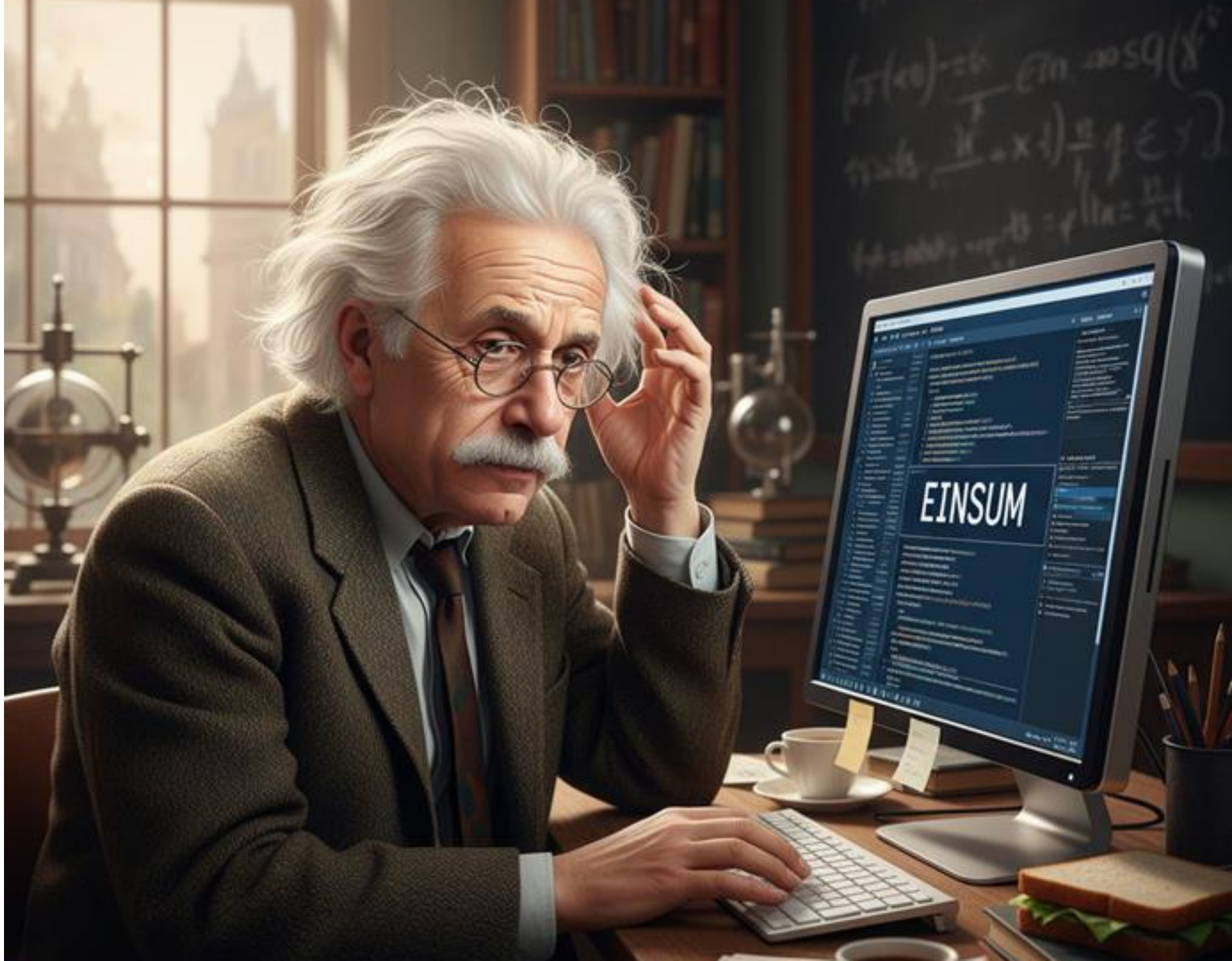


Do problems 5.1 => 5.3

Thanks for coming!

Explore: Bonus & Einsum & Finish the rest.

Einsum



`einsum` examples!

```
>>> a = np.arange(4)  # (4,)
>>> b = np.arange(4)  # (4,)

>>> np.einsum('i,i->i', a, b)
>>> np.einsum('i,j->ij', a, b)
>>> np.einsum('...i,...i->...', a, b)
```

```
array([0, 1, 4, 9])    # (4,)

array([[0, 0, 0, 0],
       [0, 1, 2, 3],
       [0, 2, 4, 6],
       [0, 3, 6, 9]])  # (4, 4)

np.int64(14)           # (,)
```