Today:

- concatenating matrices
- images in MATLAB

Reading: Ch 2 of main text
Ch 2 of WLIL

Concatenating matrices

Ex:

$$\underbrace{\begin{bmatrix} 1 & 3 & 2 \\ 4 & 7 & 9 \end{bmatrix} \quad \begin{bmatrix} 1 & 7 \\ 7 & 1 \end{bmatrix}}$$

$$\begin{bmatrix} 1 & 3 & 2 & 1 & 7 \\ 4 & 7 & 9 & 7 & 1 \end{bmatrix}$$

horizontal concatenation
need same # rows

$$\underbrace{\begin{bmatrix} 1 & 3 & 2 \\ 4 & 7 & 9 \end{bmatrix} \quad \begin{bmatrix} 2 & 2 & 2 \end{bmatrix}}$$

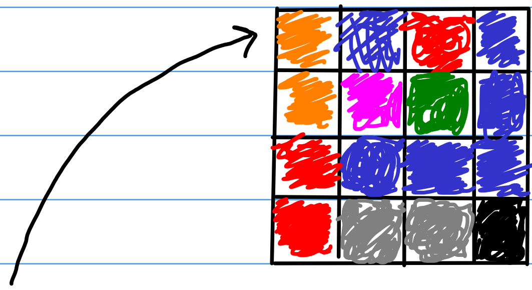
$$\begin{bmatrix} 1 & 3 & 2 \\ 4 & 7 & 9 \\ 2 & 2 & 2 \end{bmatrix}$$

vertical concatenation
need same # columns

In MATLAB: A B matrices

horizontal concatenation [A,B] [A B]
vertical concatenation [A;B]

Def: A (digital) pixel is a solid-colored square.



4×4 image

$4 \times 4 \times 3$

color of a pixel is given by RGB values

$(r, g, b) \to$ determine a color

$0 \leq r, g, b \leq 255$

Possible colors: $256 \times 256 \times 256 = 16777216$

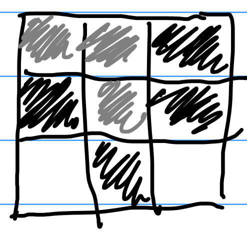
Pure, bright red $= (255, 0, 0)$

Pure, dark red $= (150, 0, 0)$

Dark black $= (0, 0, 0)$

Bright teal $= (0, 255, 255)$

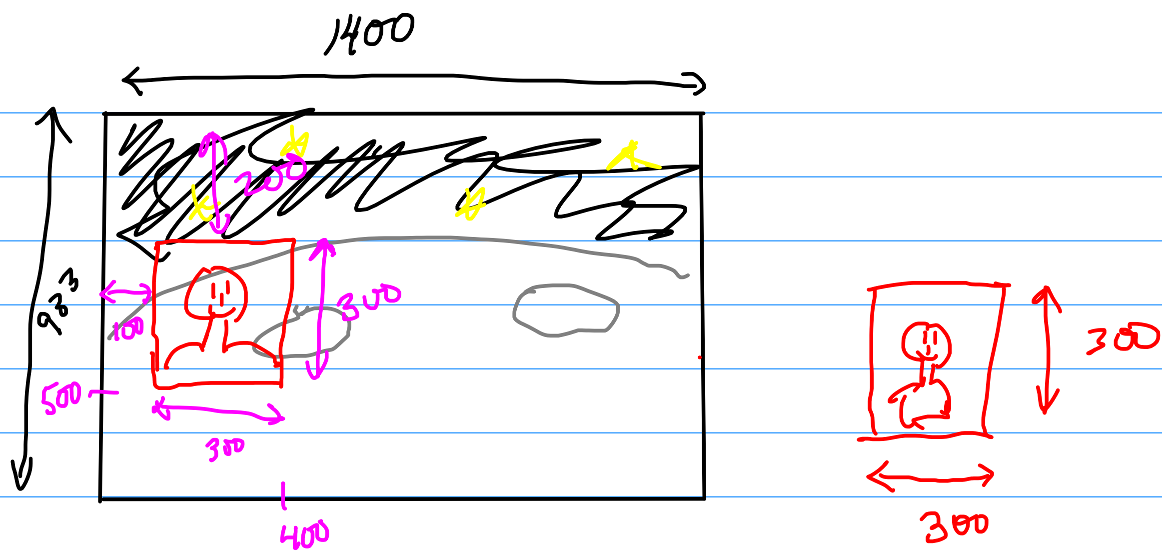
Grayscale image:



$$\to \begin{bmatrix} 100 & 100 & 0 \\ 0 & 100 & 0 \\ 255 & 0 & 255 \end{bmatrix}$$

rep. by a single integer between

0 (black) and 255 (white)



B(201:500, 101:400, :) = AA;

Linear combinations :

vectors : $\begin{bmatrix} 1 \\ 2 \\ 3 \\ 9 \end{bmatrix}$ column vector $\begin{bmatrix} 4 & 0 & 7 \end{bmatrix}$ row vector

matrices : $\begin{bmatrix} 1 & 2 & 9 & 3 \\ 4 & 7 & 0 & 6 \end{bmatrix}$

scalars : 2, $\sqrt{5}$, π

These are the main players in linear algebra!

Linear algebra involves algebra ← add, subtract, multiply

Scalar multiplication :

$$a \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} = \begin{bmatrix} av_1 \\ av_2 \\ \vdots \\ av_n \end{bmatrix} \qquad a \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{bmatrix} = \begin{bmatrix} ab_{11} & ab_{12} & \\ ab_{21} & ab_{22} & \\ & & \ddots \end{bmatrix}$$

Example: $3 \cdot \begin{bmatrix} 4 & 0 & 2 \end{bmatrix} = \begin{bmatrix} 12 & 0 & 6 \end{bmatrix}$

$$2 \cdot \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} = \begin{bmatrix} 2 \\ 4 \\ 6 \end{bmatrix}$$

$$4 \cdot \begin{bmatrix} 1 & 9 \\ 2 & 1 \end{bmatrix} = \begin{bmatrix} 4 & 36 \\ 8 & 4 \end{bmatrix}$$

Vector/Matrix addition:

$$\begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_n \end{bmatrix} + \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} = \begin{bmatrix} u_1+v_1 \\ u_2+v_2 \\ \vdots \\ u_n+v_n \end{bmatrix}$$

Similarly for matrices!

Example: $\begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} + \begin{bmatrix} 2 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix}$

$$\begin{bmatrix} 3 \\ 0 \\ 4 \end{bmatrix} + \begin{bmatrix} 1 & 9 & 3 \end{bmatrix} = \text{NONSENSE!}$$

$$\begin{bmatrix} 1 & 3 & 1 \\ 0 & 1 & 0 \end{bmatrix} + \begin{bmatrix} 2 & 0 & 1 \\ 4 & 1 & 1 \end{bmatrix} = \begin{bmatrix} 3 & 3 & 2 \\ 4 & 2 & 1 \end{bmatrix}$$

Def: A <u>linear combination</u> is what we get by using vector addition and scalar multiplication