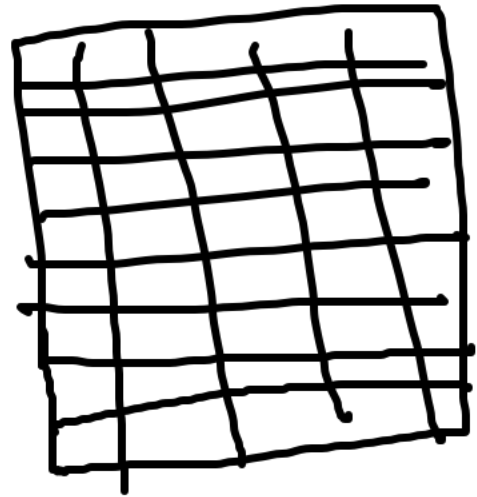
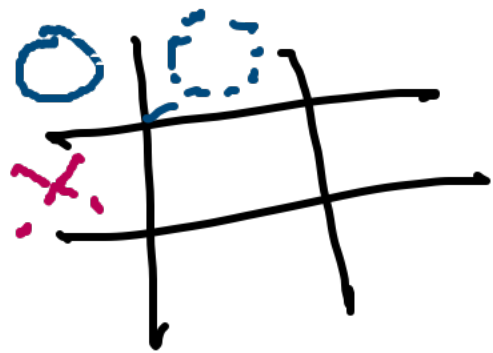


Introduction to Machine Learning

before AI, computers had to be told exactly what to do

Classic AI: search instead learning



search → learning

Neural Networks, Deep Learning, Reinforcement Learning

Supervised Classification

classification: fit / label new data based previously data
discrete classes / labels to each data point / input

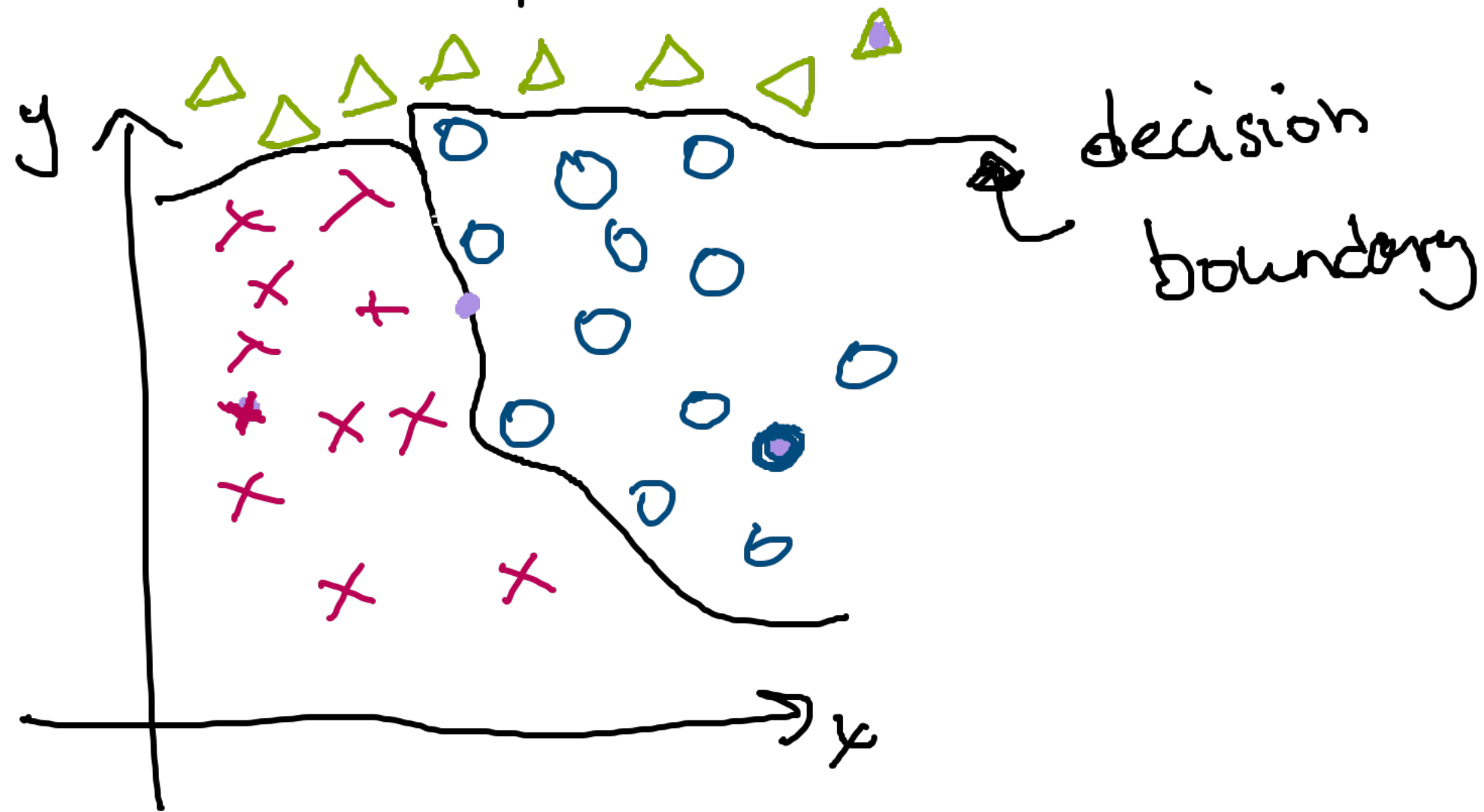
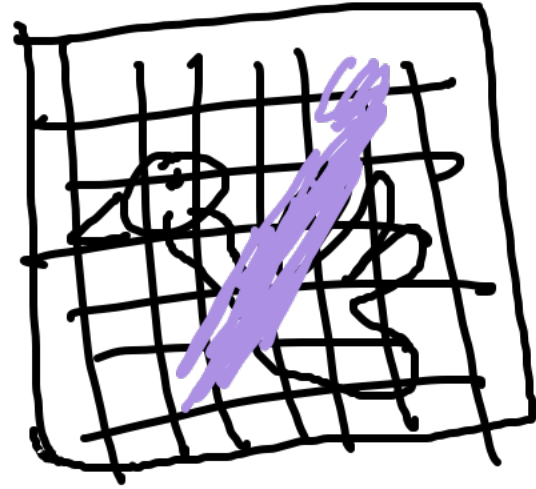


Image Classification : assign labels to an input image



"bird"

Class labels: "bird", "cat", "dog"

data-driven : give our AI
labeled example images
"ground truth"

Challenges:

Scaling

Occlusion: part of img is
hidden/behind
something

illumination: lighting

Nearest Neighbor Classifier

remember our examples (training data)

given new input, compare with examples & assign same label

as the closest image that we've seen.

$$d_1(I_1, I_2) = \sum_p |I_1^p - I_2^p|$$

$$A = \begin{bmatrix} 4 & 2 \\ 3 & 4 \end{bmatrix} = \begin{bmatrix} 4 \\ 3 \\ 2 \\ 4 \end{bmatrix}$$

$$d_1(A, B)$$

$$= \sum_p \left| \begin{bmatrix} 4 \\ 3 \\ 2 \\ 4 \end{bmatrix} - \begin{bmatrix} 0 \\ 7 \\ 1 \\ 7 \end{bmatrix} \right| = \sum_p \begin{bmatrix} 4 \\ 4 \\ 1 \\ 3 \end{bmatrix} = 12$$

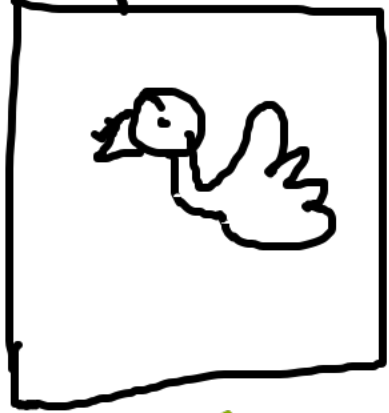
$$B = \begin{bmatrix} 0 & 1 \\ 7 & 7 \end{bmatrix} = \begin{bmatrix} 0 \\ 7 \\ 1 \\ 7 \end{bmatrix}$$

min d_1

$$d_2(I_1, I_2) = \sqrt{\sum_p (I_1^p - I_2^p)^2}$$

k-Nearest Neighbors Classifier

input



bird

$k=5$

bird } 3

bird }

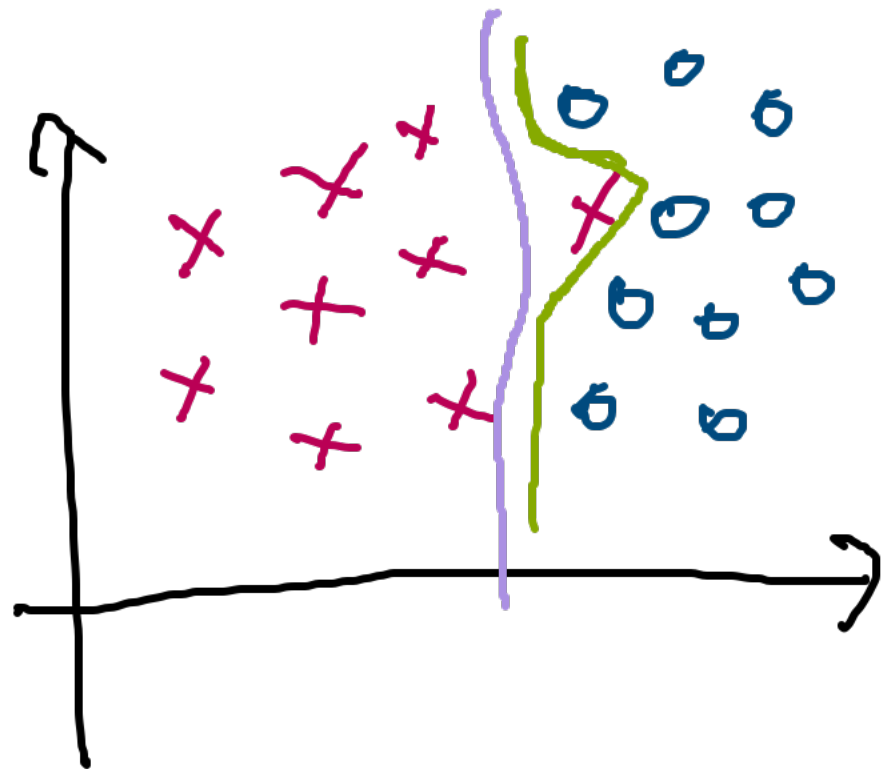
cat - 1

dog - 1

$k=1$: Nearest Neighbor

as k increases \rightarrow smoother
decision boundary
possible incorrect classification

How do
we choose
 k ???



$k=1$

$k=5$

Pros

- simple
- no training time

Cons

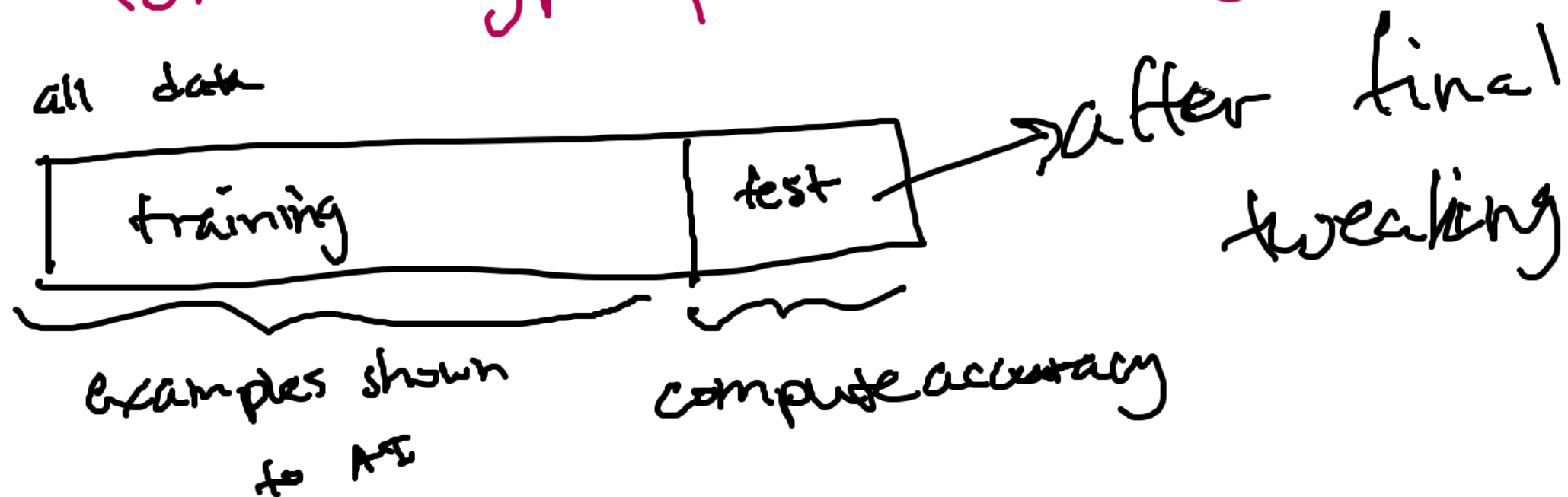
- not as accurate as state-of-the-art
- longer to test

hyperparameter: "k" in kNN, d_1 or d_2
variable in our ML algorithm that we have to tune
no obvious "correct" choice.

accuracy: $\frac{\text{number of correct classifications}}{\text{number of classifications}}$

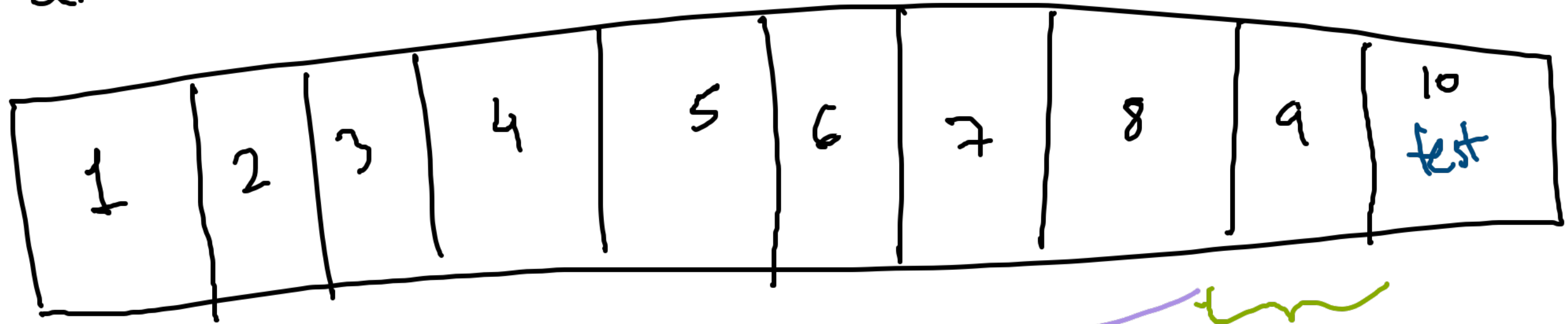
percentage
how 'well' our
model performs

do not use testing set
for hyperparam. tuning!



Cross validation

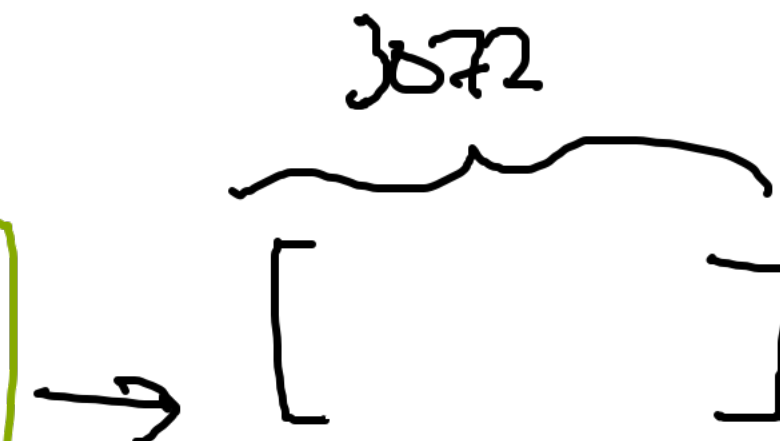
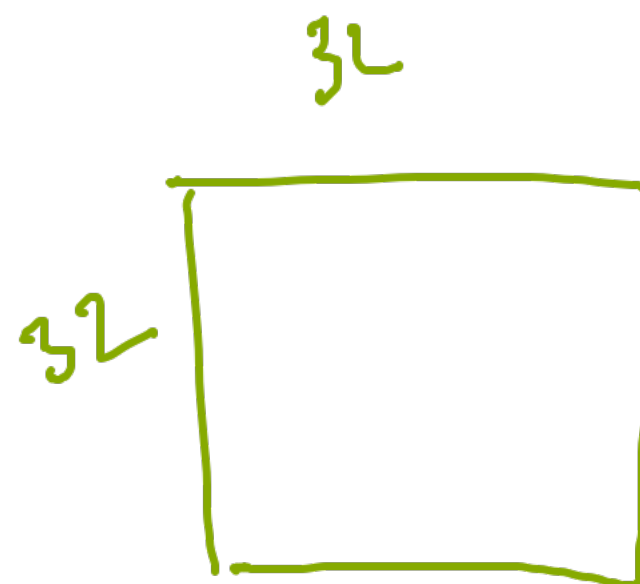
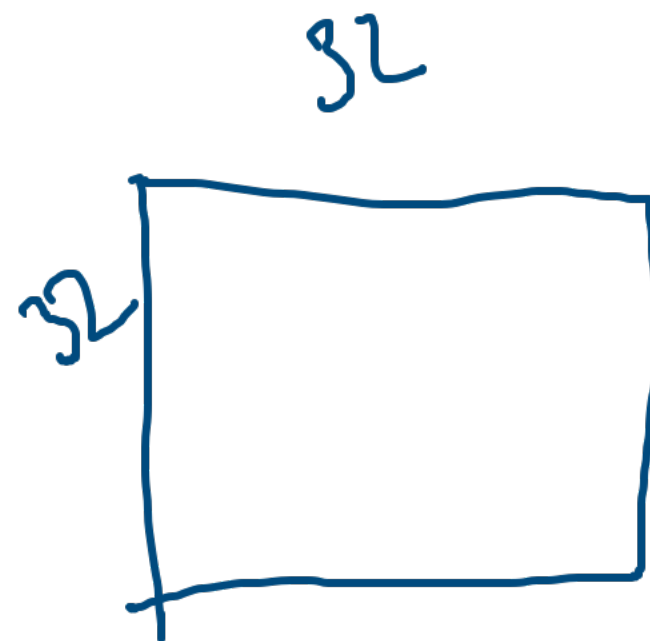
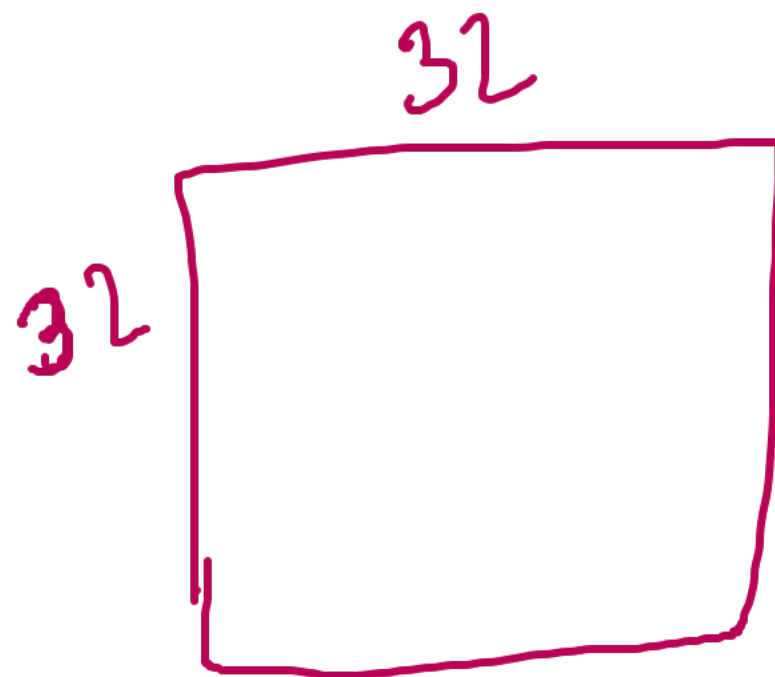
all data



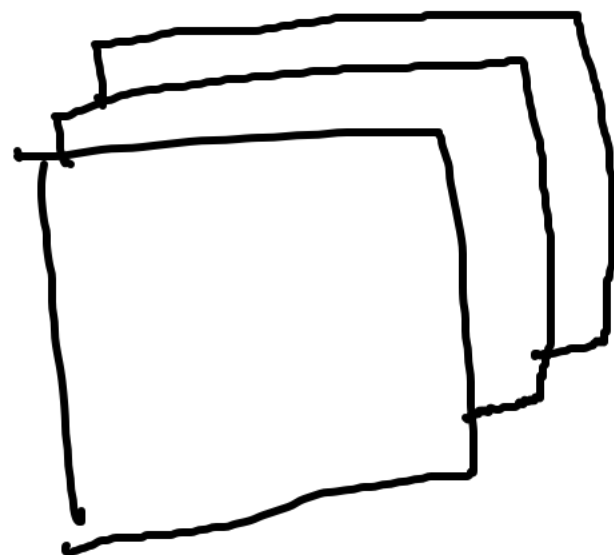
validation

validation

CIFAR-10



R
G
B



full
color
image

$$R : 32 \cdot 32 = 1024$$

$$B : 32 \cdot 32 = 1024$$

$$G : 32 \cdot 32 = 1024$$

$$\frac{3072}{\text{giant list}}$$

