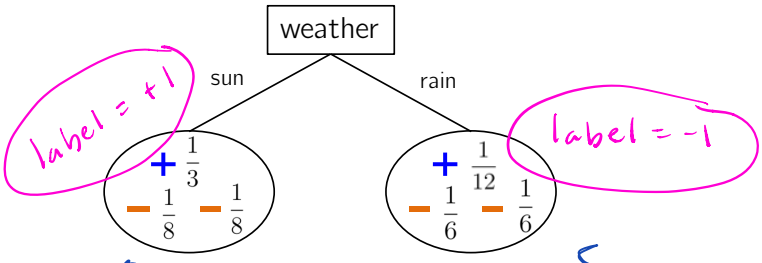
Midterm 2 Practice Problems *(find and work with a partner)*

1. *AdaBoost with Decision Stumps.* Say I am at iteration t of AdaBoost with $n = 6$. I train a classifier with the current weights (shown for each example below) and this is the resulting decision tree:



   (a) If I use a threshold of 0.5, what are the labels of each leaf? In other words, if a new example had *weather*="*sun*", would I classify it as +1 or −1? And if the example had *weather*="*rain*"?

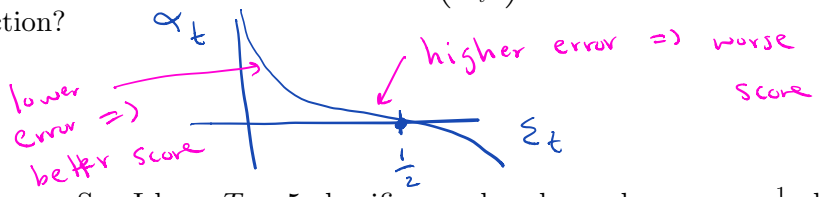
$p(+) = \frac{\frac{1}{3}}{\frac{1}{3}+\frac{1}{8}+\frac{1}{8}} = \frac{4}{7} > 0.5$

$p(+) = \frac{\frac{1}{12}}{\frac{1}{12}+\frac{1}{6}+\frac{1}{6}} = \frac{1}{5} < 0.5$

   (b) What is the weighted training error ϵ_t for this classifier?

$\epsilon_t = \frac{1}{8} + \frac{1}{8} + \frac{1}{12} = \boxed{\frac{1}{3}}$

   (c) We compute the score of this model as $\alpha_t = \frac{1}{2}\ln\left(\frac{1-\epsilon_t}{\epsilon_t}\right)$. What is the intuition behind using this scoring function?



2. *Ensembles reducing error.* Say I have $T = 5$ classifiers and each one has an $r = \frac{1}{3}$ chance of being incorrect. If I run all of them on a new example, the number of votes for the wrong class could be $R = 0, 1, 2, 3, 4$, or 5. Of these options, which would result in an incorrect classification overall? Compute $P(R = k)$ for each of these options, then use this result to compute the overall probability of an incorrect classification.

would result in incorrect classification

$P(R=5) = \binom{5}{5}\left(\frac{1}{3}\right)^5$

$P(R=4) = \binom{5}{4}\left(\frac{1}{3}\right)^4\left(\frac{2}{3}\right)$

$P(R=3) = \binom{5}{3}\left(\frac{1}{3}\right)^3\left(\frac{2}{3}\right)^2$

$P(\text{incorrect}) = 0.21$

↑ less than $\frac{1}{3}$!

3. With $n = 2$ training examples, how many unique datasets can I generate with bagging? What about $n = 3$?

$n=2$: $\{x_1, x_1\}$, $\{x_1, x_2\}$, $\{x_2, x_2\}$ → 3

$n=3$: $\{x_1, x_1, x_1\}$, $\{x_1, x_1, x_2\}$, ⋮ → 10

4. Say you are given the three confusion matrices below, which correspond to three different thresholds (i.e. if the threshold is t, I declare the label positive if $p(y|x) \geq t$).

Predicted class

True class	N	P
N	3	7
P	2	18

$FPR = \frac{7}{10} = 0.7$ $TPR = \frac{18}{20} = 0.9$

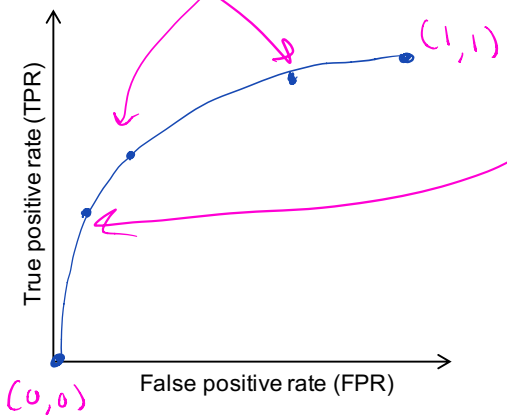
	N	P
N	7	3
P	5	15

$FPR = \frac{3}{10} = 0.3$ $TPR = \frac{15}{20} = 0.75$

	N	P
N	9	1
P	10	10

$FPR = \frac{1}{10} = 0.1$ $TPR = \frac{10}{20} = 0.5$

(a) For each confusion matrix, add the corresponding point on the axes below to create a ROC curve (also include the two points that are always on a ROC curve).



(b) Which confusion matrix corresponds to a low threshold t? Which one corresponds to a high threshold?

first last

(c) For this example, what confusion matrix would correspond to the "best" point on an ideal ROC curve?

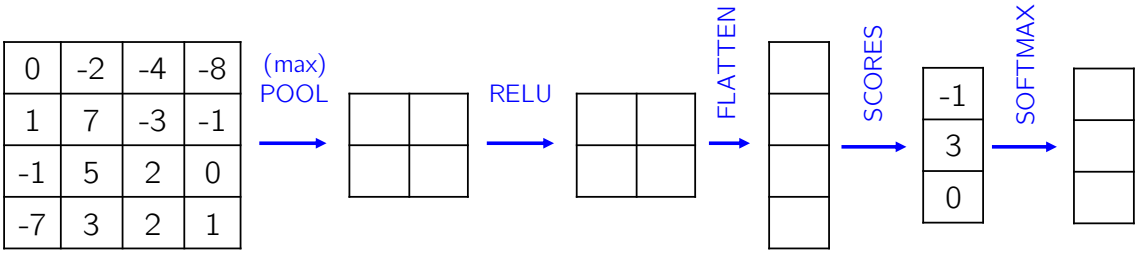
10	0
0	20

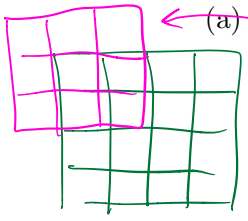
(d) Why do we apply the threshold during testing but not training?

Exercises!

(e) Think of a scenario (that we have not discussed in class/lab) where a low threshold would be desirable. Where a high threshold would be desirable?

5. Say I have the following output of a CONV layer on the left. Assume no bias terms throughout.

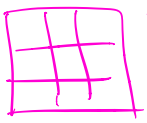




(a) If my original input was also 4×4 and I used one convolutional filter with size 3×3 (no bias), how much zero padding would I need? How many parameters would I need to learn just for this CONV layer?

padding of 1 around entire image

← image



3x3 filter

9 parameters

(b) Fill in the steps POOL (2×2 with stride 2), RELU, FLATTEN.

(c) Say the scores are as given above for three potential labels $\hat{y} \in \{1, 2, 3\}$. Compute the SOFTMAX function to obtain a probability distribution over these three classes. What would you choose for the predicted label $\hat{y}$?

in class

(d) If the true class was in fact $y = 2$, what is the cross-entropy loss?

(e) In the input had been a matrix of zeros, what would the scores be? What would the probability distribution (output of SOFTMAX) be?