CS 412 Take-home Midterm

Due: April 9th - 8pm Central time

Name: _____

UIC NetID: _____

UIN: _____

Please make sure all of your questions are properly labeled before you submit. No late submissions will be accepted

Question	Max Points	Earned Points
1	40	
2	15	
3	15	
4	30	
Total	**125**	

- You are allowed to use your notes and the book to help with this exam
- All work that is given must be your own
- You will submit your assignment to gradescope when you are finished.
- You may answer the questions using any format you'd like, e.g, typed, handwritten, tablet etc.
- Good luck! I will be on slack to answer clarification questions. Please use the #exam channel

1 Short Answer

Answer the following answers. For each part, **explain your answer**

a) Copy the following sentence and sign with your signature.
"All of the following answers are my own work".

b) What is the purpose of regualarization? What is the difference between L1 and L2 regularization?

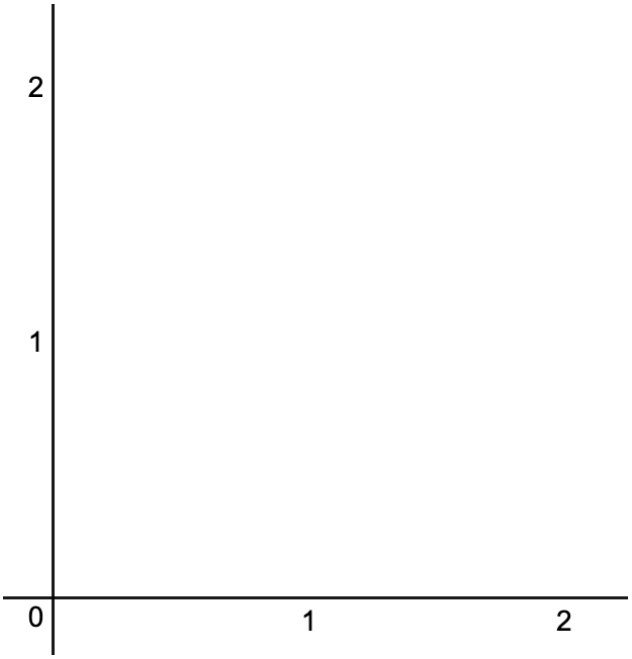
c) Why are decision trees commonly used in ensemble classifiers?

d) Why do neural networks require an activation function, e.g. ReLU or sigmoid?

e) Can you apply a kernel transformation to help with neural network modeling? Would you want to do this or not? Why or why not?

f) Between nearest neighbors, SVM and neural network, in the worst-case, which takes the longest to retrain if given a new data point? Why?

g) Why does bagging reduce variance?



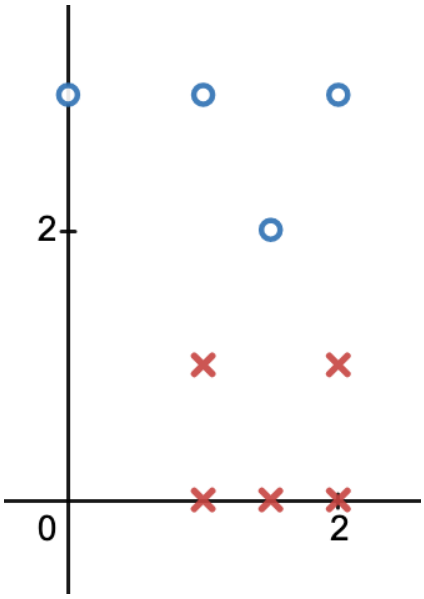
h) Suppose I've given you an arbitrary decision boundary in 2D space and I ask you to determine whether a decision tree or a neural network produced the result. What would you look for that would indicate one model or the other?

2 Support Vector Machines

Answer the following questions related to Support Vector Machines. Let the "X" points be positive. Use the following loss function for the SVM.

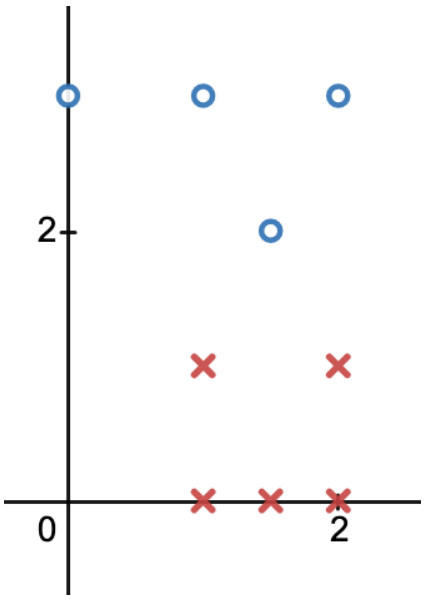
$$\min_{w} \frac{1}{2}\|\mathbf{w}\|^2 + C\sum_t \xi^t$$

a) Draw the hard-margin SVM on the dataset below. Draw the decision boundary as a solid line and the margin boundaries as dashed lines. Circle the support vectors



b) What are the weights $(\beta_0, \beta_1, \beta_2)$ for the model from part a)?

c) Draw the decision boundary and margin boundary for the SVM drawn if C = 0.1. Circle the support vectors as well. Use the loss function from the previous page.

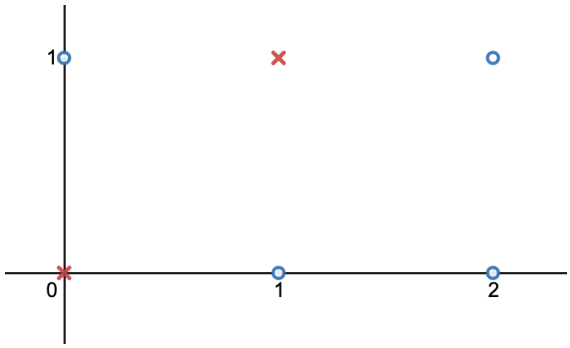


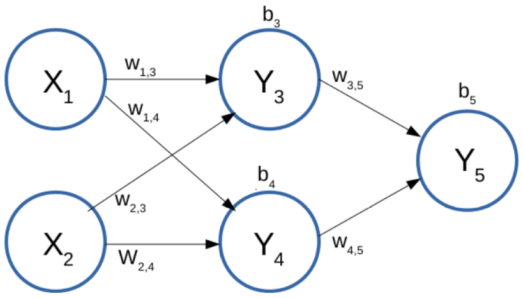
d) Is this model the same or different from the model before? Why or why not?

3 Neural Networks

Consider the following data set and neural network model. Let the "X" points be positive. **Use the sign function as your activation function**

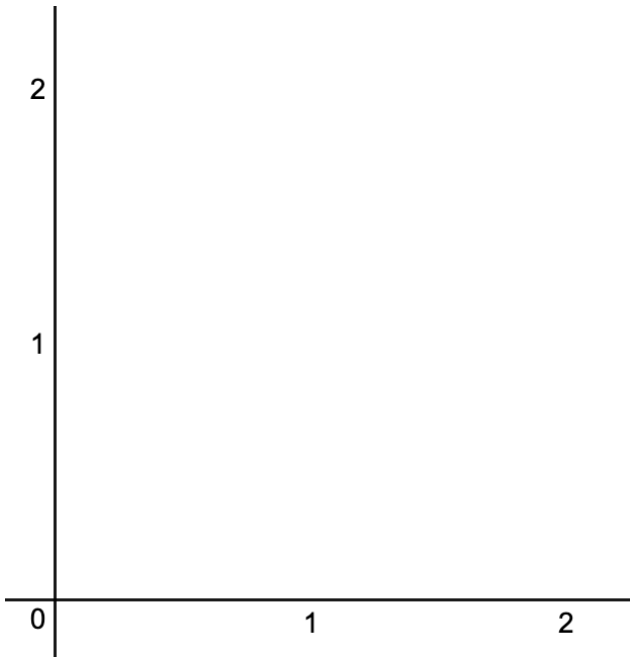
a) Fit the following data with a neural network with all weights in $\{-1, 0, 1\}$ such that the positive "X" points are all on the boundary y_5. Draw the boundaries of your internal nodes y_3 and y_4 on the graph. Be sure to indicate which direction is positive.





b) Give the weights for your internal nodes y_3 and y_4. All your weights should be in $\{-1, 0, 1\}$

c) Now draw the points in the transformed y_3, y_4 space. Let y_3 be the x-axis and y_4 be the y-axis. Remember to use the sign function as your activation.

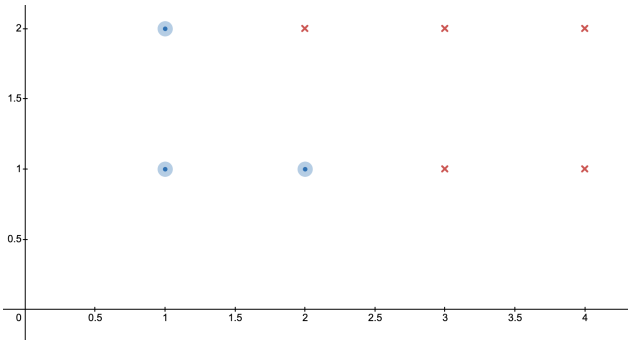


d) Draw your decision boundary y_5 on the above graph such that all the positive "X" points lie on the boundary. Recall that the x points are positive.

e) Give your weights for y_5, that are all in $\{-1, 0, 1\}$

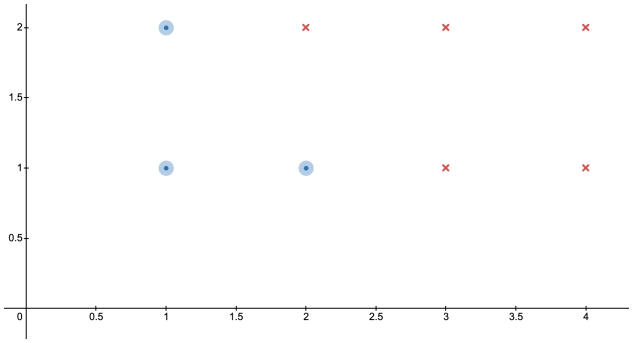
4 Boosting

Perform 3 iterations of a boosting algorithm on the following data. Your boosting algorithm should double the weights of incorrect points at each step and the weight of each model $\alpha = \frac{1-\epsilon}{\epsilon}$. **You should use only vertical or horizontal lines as your weak learners**.



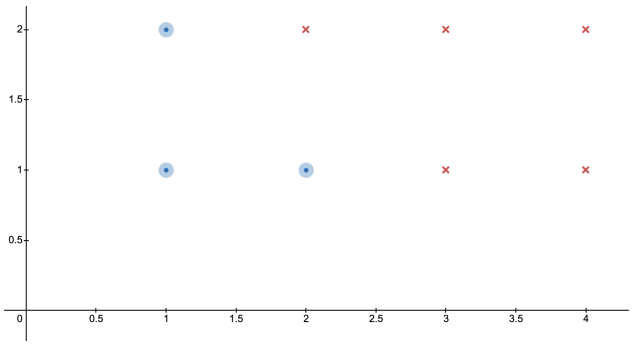
a) Draw your first weak leaner above. What is it's error (ϵ)?

b) What is the weight (α) for the model in part a)?



c) Draw your second weak leaner above. What is it's error (ϵ)?

d) What is the weight (α) for the model in part c) (on the last page)?



e) Draw your third weak leaner above. What is it's error (ϵ)?

f) What is the weight (α) for the model in part e)?

g) What is the total training error for this boosted algorithm after 3 models?

h) **Programming portion**. Use the `sklearn.ensemble.AdaBoostClassifier` on the 2D digits training data from the homework. *Which value of* `n_estimators` *produces the best model? Keep all other values as their default. Defend your answer with data and figures. Hint: use cross validation*