COMP 7745/8745: Machine Learning

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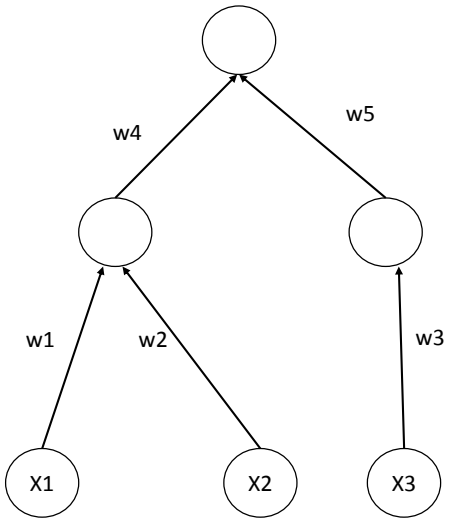
Spring 2018: Homework 1

Due Dates: February 19, 2016 in class or ecourseware, code for Q6 in ecourseware

1. Can the following functions be represented using decision trees? If your answer is yes, draw the corresponding tree, if your answer is no, briefly state why. (12 points)
   - $A \wedge \neg B$
   - A XOR B
   - $A \vee (B \wedge C)$
2. Can the following functions be represented using perceptrons. If your answer is yes, compute the weight vector for the perceptron such that it can classify all instances of the functions correctly. Give a one line justification if your answer is No. (12 points)
   - $A \vee B$
   - $\neg A \vee B$
   - A XOR B
3. For each of the following, state whether true of false with a brief justification. (20 points)
   (a) A 2-layered neural network where each perceptron is a linear unit has the same expresiveness as a 2-layered neural network where each perceptron is a sigmoid unit.
   (b) Given a training dataset with N features, the number of nodes in any decision tree is guaranteed to be lesser than or equal to N.
   (c) A neural network with a hidden layer is as expressive as a decision tree.
   (d) Given the optimal learning rate, the gradient descent algorithm will always converge for a perceptron regardless of the dataset or number of features.
4. Run the ID3 algorithm (manually) for the following dataset to classify whether students like a restaurant or not. (10 points)

Price	**Fast**	**On Campus**	**Like**
$	No	No	No
$	Yes	Yes	No
$$	No	Yes	No
$$	Yes	Yes	Yes

5. Compute the backpropagation update equations for each weight in below figure given the input $X1 = -1$, $X2 = 1$, $X3 = -1$ with the desired response $y = 0$. Let the weights be initialized as follows: $w_1 = -1$, $w_2 = 2$, $w_3 = 1$, $w_4 = 1$ and $w_5 = 2$. (You don't need to explicitly compute the sigmoid values, just leaving them symbolically as S(.) is sufficient). (10 points)



6. In this question, you will experiment with the perceptron weight learning rule. You have been given 2 datasets d-10.csv, d-100.csv. The first line in each of these datasets is just a column identifier and each subsequent line corresponds to one instance where the last attribute is the class value. Implement the online perceptron weight learning algorithm (not the sigmoid gradient descent rule). Initialize all the weights randomly between 0 and 1. Remember to add a bias term. Present results as in the following table for each dataset.

Learning rate	**Error after 100 epochs**	**Error after 500 epochs**

Consider an epoch as a complete pass over the entire dataset. Compute the error as the % of mis-classifications. Very briefly explain your results, e.g., did the error go down on all three datasets with increased iterations, what was the effect of the learning rate, what was the effect of the increase in dimensionality (number of attributes) with the error, etc. (18 points)

7. (18 points) Download weka from `https://www.cs.waikato.ac.nz/ml/weka/downloading.html`. Here, you will use Weka to experiment with J48(trees/J48) and neural networks (functions/multilayer perceptron) using the wines.csv dataset. In this dataset, the first

line is just the attribute names and each subsequent line specifies one instance where the final attribute is the class value.

Analyze the performance of the following algorithms using the average F-1 score obtained using 5-fold and 10-fold cross-validation.

1. For J48, vary the confidence factor in J48 between 0.1 and 0.5 (smaller confidence factor results in larger pruning of the tree) and report the average F-1 scores given by Weka for each case.

3. For Neural networks, vary the number of hidden layers (1,2) and the learning rate (0.01,0.1,0.2). Report the cross-average F1-scores given by Weka for each of the 6 cases.

Briefly describe your understanding of the overall results.