Homework #5: Chapters 18, 19, 20, and 22

The following exercises are due at the beginning of class on Friday, April 30.

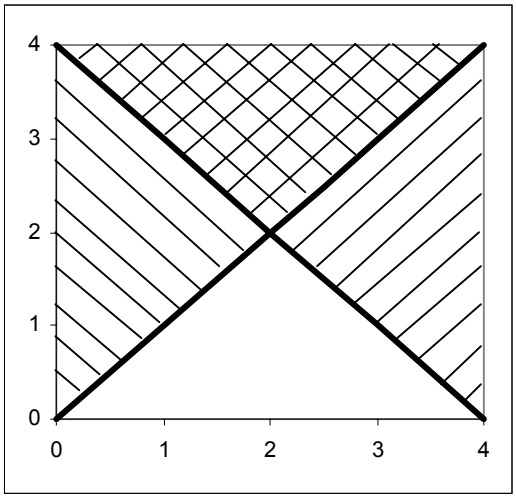
1. *[15 pts.]* Consider the training set given below.

Example	Type	Garage	Bedrooms	Bathrooms	Goal Predicate
X_1	TownHouse	Yes	2	1.5	Yes
X_2	Condo	No	2	1.5	No
X_3	Apartment	Yes	2	1	No
X_4	TownHouse	Yes	4	1	No
X_5	TownHouse	Yes	3	1.5	Yes
X_6	Condo	Yes	1	1	No
X_7	TownHouse	No	3	1.5	No
X_8	TownHouse	Yes	1	1.5	Yes
X_9	Apartment	Yes	2	1.5	No

   Use decision tree learning to induce a decision tree for this set. When choosing the attribute to split on, always choose the attribute that immediately classifies the maximum number of examples. Break ties by choosing the left-most of such attributes in the table.

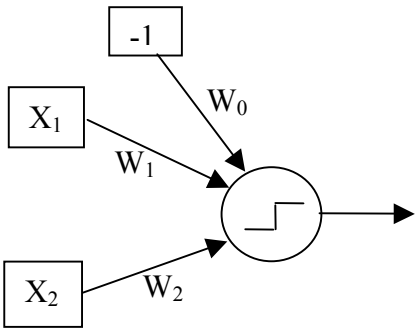
2. *[35 pts.]* For this problem, assume that the hypothesis space only contains hypotheses whose candidate definitions are positive conjunctive sentences (i.e., a set of unnegated atoms separated by AND ($\wedge$) symbols). Thus, the immediate generalization or specialization of a sentence should differ by only a single conjunct.
   a. Consider the training set given in exercise #1 above. Convert the training set into a set of first-order logic description and classification sentences. Use the predicates *Type(x,t)*, *Beds(x,b)*, *Baths(x,b)* and *Garage(x,g)* in your description sentences and *Q(x)* for your goal predicate.
   b. Which of these examples is the candidate definition *Beds(x,2)* $\wedge$ *Baths(x,1.5)* consistent with? Which ones result in false positives and which ones in false negatives?
   c. Give all the immediate specializations of `Type(x,TownHouse)` $\wedge$ `Garage(x,Yes)` that are consistent with examples X_3 to X_5.
   d. Give all the immediate generalizations of `Type(x,Condo)` $\wedge$ `Beds(x,3)` $\wedge$ `Garage(x,No)` that are consistent with example X_2.
   e. Use version space learning on the training set. Assume that the examples are received in the order given. Show your G-set and S-set after each new example is received.

3. *[15 pts.]* For this problem you will construct a series of neural networks, building up to a neural network that can recognize a function that is not linearly separable. All of the neural networks will have two inputs: x and y. Both x and y are real numbers and their values are restricted such that $0 \le x \le 4$ and $0 \le y \le 4$. Use threshold functions for all nodes in your neural networks and assume that the threshold function returns 1 when its input is ≥ 0 and returns 0 otherwise. Do not use a learning algorithm to develop the neural networks in this problem.
   a. Create a single layer feed-forward neural network (a perceptron) to recognize when the input y is greater than or equal to the input x (i.e. $y \ge x$). This corresponds to the area in the graph above the line from the lower left to upper right.
   b. Create a single layer feed-forward neural network (a perceptron) to recognize when the input y is greater than or equal to 4 minus the input x (i.e. $y \ge 4-x$). This corresponds to the area in the graph above the line from the upper left to lower right.
   c. Create a multilayer feed-forward neural network to recognize when y is $\ge$ both x and 4-x. This corresponds to the double hash marked area in the graph. Obviously, this is not a linearly separable function.



Hints: Approach part c by considering how to combine your answers from parts a and b. Test your neural networks thoroughly to be sure that they perform as expected for various combinations of inputs in the range given (especially near boundaries of the function and input ranges)

4. *[15 pts.]* Use the perceptron learning algorithm to teach the perceptron shown to the right to recognize implications (i.e. $X_1 \rightarrow X_2$). Assume that a threshold activation function is being used and that the threshold function returns 1 when its input is ≥ 0 and returns 0 otherwise. For initial weights, use $W_0=0.2$, $W_1=-0.5$, and $W_2=0.1$. For the learning rate, use $\alpha=0.1$. Use only the examples in the table to the right in your learning process.



X_1	X_2	out
0	1	1
1	0	0
0	0	1
1	1	1

Stop the training once the weights remain unchanged for one full pass through the examples. The examples must be used in the order given. Start again with the first example whenever you exhaust all of the examples but have not yet reached the stopping criteria. Show all of the intermediate calculations and values (not just the answer or the updated weights after each example).

5. *[20 pts.]* Consider the lexicon and grammar given in Figures 22.3 and 22.4 of the book (p. 797). For each sentence below, determine if it is generated by the grammar. Show the corresponding parse trees. In the lexicon given in the book, "| …" indicates that other words can have that part of speech. However, you should only use the words explicitly listed. Do not use your knowledge of English to expand the "| …" to include other words.
   a. Aristotle and John see gold.
   b. Me kill in glitter.
   c. I smell but the wumpus stinks.
   d. You see nearby gold.