

CS472
Foundations of Artificial Intelligence
Prelim II
November 19, 2003

Name:

Netid:

Instructions: You have 50 minutes to complete this exam. The exam is a closed-book exam. There are 4 sets of questions.

#	description	score		max score
1	decision trees and version spaces	_____	/	20
2	general machine learning	_____	/	9
3	neural networks	_____	/	21
4	FOL and the resolution algorithm	_____	/	20
Total score:		_____	/	70

Decision Trees and the Version Space Algorithm: (20 points total)

Consider the following (entirely fictional) scenario:

After much discussion, and in response to increasing complaints from CS undergraduates, the professors in Cornell's CS department have decided to abolish all final exams!! In place of the exams, they will use a machine learning algorithm to determine whether or not a student gets an 'A' in the course. In particular, they decide to use Quinlan's ID3 algorithm for decision tree induction. In addition, they decide to base decisions on three features: (1) the student's level of class **Participation**, (2) how well the student has done on **Homework**, and, perhaps surprisingly, (3) the student's ability to play ice **Hockey** :). The table below shows the data we are using to train the decision tree for CS472. It lists eight examples that include "A students" and "below A students". (The "A students" are denoted via a **Class** value of '+'; the "below A students" are denoted via a **Class** value of '-'.)

	Class	Participation	Homework	Hockey Skills
1	-	lots	high	expert
2	-	medium	high	novice
3	+	lots	medium	novice
4	-	medium	high	novice
5	-	medium	medium	expert
6	+	little	medium	novice
7	-	lots	high	novice
8	+	lots	medium	expert

1. (10 pts) Show the decision tree that would be created by an ID3-style algorithm for decision tree induction given all of the above examples as training instances. (It is not necessary to show any calculations of the decision criterion.)

2. (3 pts) Consider the case of Mitchell's *version space algorithm* (also known as the *candidate elimination algorithm*) as applied to this problem and the above training instances. How would the G set and S set be initialized?
3. (7 pts) Show the version space after seeing example 1.

General Machine Learning: (9 points total)

1. (3 pts) Describe (in a complete sentence) one advantage of ID3 over the version space algorithm.

2. (3 pts) Describe (in a complete sentence) one advantage of the version space algorithm over ID3.

3. (3 pts) Describe (in a complete sentence) one advantage of the k-nearest neighbor (k-nn) algorithm over ID3.

Neural Networks (21 points)

1. Consider a perceptron with inputs x_1 and x_2 that have associated (learned) weight values of $w_1 = 1$ and $w_2 = -3$, respectively. (We assume an extra input x_0 fixed at -1 with weight $w_0 = 0$ to capture the threshold.)

- (2 pts) Show pictorially the perceptron described above.

- (6 pts) Draw the decision surface of the perceptron; that is, indicate which portion of the x_1, x_2 plane produces outputs of $+1$ and 0 .

- (7 pts) Show the weight update rule for the perceptron learning algorithm. Be sure to explain what each term in the rule means.

2. (3 pts) Describe the key difference between reinforcement learning and supervised inductive learning from examples.
3. (3 pts) Among the approaches we studied for reinforcement learning were (1) adaptive dynamic programming and (2) temporal-difference learning. The two approaches to estimating utility values for states are closely related in that both try to make local adjustments to the utility estimates in order to make each state “agree” with its successors. Describe one of the key differences between the approaches.

First-Order Logic and Resolution Theorem-Proving (20 points total)

- (5 pts) Consider the following statements in English. Some of the statements have been converted to first-order logic. Provide the conversion to first-order logic for each of the remaining statements. Assume that only the following predicates are available for your use: *Dog*, *Owns*, *AnimalLover*, *Animal*, *Kills*, *Cat*. Assume also that the following constants are available: *Jack*, *Curiosity*, *Tuna*.

1. Cats are animals.

2. Tuna is a cat.

3. Every dog owner is an animal lover. $\forall x (\exists y \text{ Dog}(y) \wedge \text{Owns}(x, y)) \rightarrow \text{AnimalLover}(x)$

4. Jack owns a dog.

5. No animal lover kills an animal. $\forall x \text{ AnimalLover}(x) \rightarrow \forall y \text{ Animal}(y) \rightarrow \neg \text{Kills}(x, y)$

6. Either Jack or Curiosity kills Tuna.

- (8 pts) Convert the knowledge base above into clausal form, i.e. into conjunctive normal form. One of the conversions has already been provided.

1.

2.

3. $\neg \text{Dog}(S(x)) \vee \neg \text{Owns}(x, S(x)) \vee \text{AnimalLover}(x)$

4.

5.

6.

- (7 pts) Prove using resolution by refutation that, *Tuna is an animal*. Show any unifiers required for the resolution. Be sure to provide a clear numbering of the sentences in the knowledge base (above) and indicate which sentences are involved in each step of the proof.