COMP3411/9814 Artificial Intelligence Term 1, 2024

Tutorial - Week 5

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1. **Decision Trees**

   Consider the task of predicting whether children are likely to be hired to play members of the Von Trapp Family in a production of The Sound of Music, based on these data:

height	hair	eyes	hired
short	blond	blue	+
tall	red	blue	+
tall	blond	blue	+
tall	blond	brown	–
short	dark	blue	–
tall	dark	blue	–
tall	dark	brown	–
short	blond	brown	–

   a. Compute the information (entropy) gain for each of the three attributes (height, hair, eyes) in terms of classifying objects as belonging to the class,
   + or – .

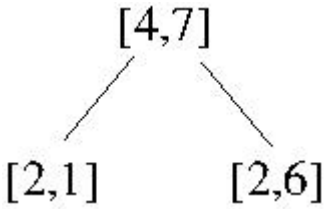
   b. Construct a decision tree based on the minimum entropy principle.

2. **Laplace Pruning**

   The Laplace error estimate for pruning a node in a Decision Tree is given by:

$$E = 1 - \frac{n + 1}{N + k}$$

   where N is the total number of items, n is the number of items in the majority class and k is the number of classes. Given the following subtree, should the children be pruned or not? Show your calculations.



3. **Perceptron Learning**

   a. Construct by hand a Perceptron which correctly classifies the following data; use your knowledge of plane geometry to choose appropriate values for the weights w_0, w_1 and w_2.

Training Example	x_1	x_2	Class
a.	0	1	–1
b.	2	0	–1
c.	1	1	+1

   b. Demonstrate the Perceptron Learning Algorithm on the above data, using a learning rate of 1.0 and initial weight values of

   $w_0 = -1.5$

   $w_1 = 0$

   $w_2 = 2$

   In your answer, you should clearly indicate the new weight values at the end of each training step. The first three steps are shown here:

Iteration	w_0	w_1	w_2	Training Example	x_1	x_2	Class	$s=w_0+w_1x_1+w_2x_2$	Action
1	–1.5	0	2	a.	0	1	–	+0.5	Subtract
2	–2.5	0	1	b.	2	0	–	–2.5	None
3	–2.5	0	1	c.	1	1	+	–1.5	Add

   Continue the table until all items are correctly classified.

4. **Computing any Logical Function with a 2-layer Network**

   Recall that any logical function can be converted into Conjunctive Normal Form (CNF), which means a conjunction of terms where each term is a disjunction of (possibly negated) literals. This is an example of an expression in CNF:

   $(A \vee B) \wedge (\neg B \vee C \vee \neg D) \wedge (D \vee \neg E)$

   Assuming False=0 and True=1, explain how each of the following could be constructed. You should include the bias for each node, as well as the values of all the weights (input-to-output or input-to-hidden and hidden-to-output, as

appropriate).

a. Perceptron to compute the OR function of m inputs:

b. Perceptron to compute the AND function of n inputs:

c. Two-layer Neural Network to compute the function
$(A \vee B) \wedge (\neg B \vee C \vee \neg D) \wedge (D \vee \neg E)$.

With reference to this example, explain how a two-layer neural network could be constructed to compute any (given) logical expression, assuming it is written in Conjunctive Normal Form.
