



## Artificial Intelligence

### – Sheet 4: Learning –

Date: 14. May 2013

#### Exercise 1 (12 Points, Ensemble learning)

Consider an ensemble learning algorithm (see e.g. the AdaBoost-algorithm) that uses simple majority voting among  $M$  learned hypotheses. Suppose that each hypothesis has error  $\varepsilon$  and that the errors made by each hypothesis are independent of the others. Calculate a formula for the error of the ensemble algorithm in terms of  $M$  and  $\varepsilon$ , and evaluate it for the cases where  $M = 5$  and  $10$  and  $\varepsilon = 0.1$  and  $0.4$ .

If the independence assumption is removed, is it possible for the ensemble error to be worse than  $\varepsilon$ ?

**Hint:** You are not getting an extremely simple formula. It will consist of a sum over  $k$  involving  $\binom{M}{k}$  (the number of  $k$  selections from  $M$ ).

Points:

\_\_\_\_\_ of 30

#### Exercise 2 (12 Points, Version-space-learning)

Apply *version-space-learning* to the following examples where it is only allowed to use **conjunctions of attributes** (i.e. no disjunctions, no negations) as hypotheses:

Number	Place	Meal	Day	Costs	Reaction
1	Mensa	vegetarian	Monday	cheap	yes
2	Cafete	meat	Monday	expensive	no
3	Mensa	meat	Tuesday	cheap	yes
4	Home	vegetarian	Wednesday	cheap	no
5	Mensa	vegetarian	Wednesday	expensive	no

Choose the examples in the same order as given in the table and explain in each cycle what happened and why.

Group / Tutor:

Name(s) & Matr. no.:

#### Exercise 3 (6 Points, Neural Nets)

Construct a feedforward net with two hidden nodes, which computes the following function (on three binary arguments)

$$(x, y, z) \mapsto \begin{cases} 1, & \text{if } (x, y, z) \in \{(1, 0, 0), (0, 1, 0), (0, 1, 1)\}; \\ 0, & \text{otherwise.} \end{cases}$$

Use the same step-function  $\text{step}_0$  as activation function for all nodes but use the additional input link (with constant input = 1) with suitable weight  $t$  for each node. Alternatively, you can also use different activation functions  $\text{step}_{t_1}$ ,  $\text{step}_{t_2}$ , and  $\text{step}_{t_3}$  for the nodes and not use any additional links.

To be submitted:

28. May 2013  
in class