**Tutorial on Computational Learning Theory**

**Q1.** Suppose the hypothesis space consists of the union of two intervals in the real line. What is the VC dimension?

**Ans.** A union of two intervals allow us to correctly label a point set of the form

⊖ ⊕ ⊖ ⊕ ⊖

All labellings for 4 points can be easily shown to be consistent with this label format. For 5 points, however, there exists the labelling ⊕ ⊖ ⊕ ⊖ ⊕ which cannot be accomplished by the union of two intervals.Thus the VC dimension is 4

**Q2.** Consider the class C of concepts of the form where ***a ,b , c ,*** and ***d*** are integers in the interval (0,9). Note each concept in this class correspondsto a rectangle with integer-valued boundaries on a portion of the ***x,*** y plane. Give an upper bound on the number of randomly drawn training examples sufficient to assure that for any target concept c in C, any consistent learner using H = ***C*** will, with probability 95%, output a hypothesis with error at most **.15.**

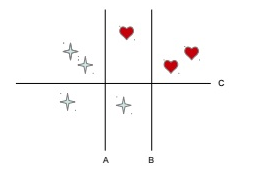
**Ans.**

Given a region in the plane bounded by the points ***(0,O)*** and (n - ***1, n*** - **I),** the number of distinct rectangles with integer-valued boundaries within this region is

δ = 0.05 and = 0.15. Since the learner is consistent substituting the values of |H|, δ and in the following formula gives us the required value for m

Qs on Ensembles

Qs 3. The diagram shows training data for a binary concept where positive examples are denoted by a heart. Also shown are three decision stumps (A, B and C) each of which consists of a linear decision boundary. Suppose that AdaBoost chooses A as the first stump in an ensemble and it has to decide between B and C as the next stump. Which will it choose? Explain. What will be the and α values for the first iteration?



Ans. It will choose B because the only example misclassified by A is correctly classified by B (the misclassified examples are assigned higher weight in the next iteration).

In the first iteration = 1/7 and

Qs 4. Given a set of 3 points (x1,+), (x2,+) and (x3,-), Adaboost algorithm is used to train a weak classifier on this data. In the first iteration, the weak classifier wrongly classifies x3 and correctly classifies the other two points. In the second iteration it wrongly classifies x1 and correctly classifies the other points. Assuming uniform initial weight distribution (D1) over the data points, what is the weight distribution for the 3rd iteration (D3)

