Final Exam

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This final exam paper has been reconstructed from memory, and as a result, some data may be missing. I hope it serves as a useful reference and aid for future students.

Problem 1: Search

Given an undirected graph G, with uniform cost c on each edge. Each node is marked with a letter. Let the starting node be A and the goal node be G. (The graph is given but not shown here.)

(a)

Draw the search tree using breadth-first search. If there are multiple nodes to expand, expand the node in alphabetical order.

(b)

Now we have a heuristic function h for each node (for example $h(A) = 5$, $h(B) = 4$, $h(C) = 3 \ldots$), and let $c = 1$. Draw the search tree using A* search. (The heuristic function is given but not shown here.)

(c)

What should the range of c be to guarantee that the heuristic function is admissible?

Problem 2: Minimax and Alpha-Beta Pruning

Given a tree T, where each leaf node is marked with its utility value. (The tree is given but not shown here.)

(a)

Draw the final alpha and beta values for each node in the tree, if the node is pruned, write NA.

(b)

Mark each pruned branch with a cross.

(c)

Mark the final path chosen by the alpha-beta pruning algorithm with a check mark.

Problem 3: CSP

(a)

State the worst case time complexity of the AC-3 algorithm, and explain why.

(b)

Given a CSP with 3 variables X, Y, Z, and 3 domains $D_X = \{1, 2, 3\}$, $D_Y = \{1, 2, 3\}$, $D_Z = \{1, 2, 3\}$. The constraints are $X < Y$, $Y < Z$. Display how the AC-3 algorithm works on this CSP.

Problem 4: Logic

Simplify $p \rightarrow (\neg(p \Leftrightarrow q))$ into a CNF form.

Problem 5: Perceptron and Neural Network

(a)

Write the formula for the perceptron weight update.

(b)

Display how the formula for logistic regression weight update is derived.

Problem 6: SVM

Given two data points $(1, 1)$ and $(-1, -1)$ (in the form of (x, y)).

(a)

Write the object function for the soft margin SVM, with constraints. Let C denote the penalty parameter.

(b)

Suppose we find $w = \min(C, 1)$ is the optimal solution for w, find the corresponding optimal b for each C (Hint: there might be multiple values for b).

Problem 7: Naive Bayes

Given a dataset with 4 features and 1 label (binary). (The dataset is given but not shown here.)

(a)

Calculate all the probabilities needed for the Naive Bayes algorithm.

(b)

Does the Naive Bayes algorithm give correct prediction on data point number 1, 3 and 5?

(c)

Suppose the strong assumption of Naive Bayes is not satisfied, how many data points are needed for the algorithm?

Problem 8: Genetic Algorithm

Suppose we develop an algorithm to evolve the weights of a neural network, instead of using back-propagation. Please describe how to set up an experiment to compare these two ways of training, as fair as possible.