UNIVERSITY OF BIRMINGHAM

School of Computer Science

Artificial Intelligence 2

Main Summer Examinations 2021

Artificial Intelligence 2

Please submit your answer as a single .pdf file via Canvas. This assignment will be graded out of 25 marks.

Question 1 Constraint Satisfaction Problem

Suppose we have 3 professors who need to deliver 6 modules (M_1-M_6) in computer science. Each module needs to be delivered in the morning of one or several days.

- M_1: Artificial Intelligence, needs to be delivered on Tuesday
- M_2: JAVA, needs to be delivered on Tuesday, Wednesday and Thursday (all 3 days)
- M_3: Data Structure, needs to be delivered on both Wednesday and Friday
- M_4: Neural Computation, needs to be delivered on both Monday and Tuesday
- M_5: Mathematics Foundation of CS, needs to be delivered on Thursday
- M_6: Software Engineering, needs to be delivered on both Thursday and Friday

Note each professor can only deliver some specific modules. Here are the details

- Professor A can deliver M_1, M_2, M_3 and M_5
- Professor B can deliver M_1, M_2, M_4 and M_6
- Professor C can deliver M_2, M_3, M_4, M_5 and M_6

Suppose a professor can only deliver at most one module in one day (e.g, Professor A can not deliver both M_1 and M_2 since both modules need to be delivered on Tuesday). Each module can only be delivered by a professor. Your task is to assign professor to modules so that each module can be successfully delivered.

(a) Formulate this problem as a CSP problem. Specifically, you need to give variables, domains and constraints. We use variable M_i to represent the ith module ($i \in \{1, \dots, 6\}$) and Professor A delivering M_i can be expressed as $M_i = A$. Domain of each variable (denoted by $d(M_i)$) is a subset of $\{A, B, C\}$. Constraints should be specified formally (i.e., using the form of $M_i \neq M_j$). **[6 marks]**

(b) Draw the constraint graph associated with your CSP. **[4 marks]**

(c) Use **backtracking search with forward checking and ordering** to find a solution of this problem. Let us assume that tie of variables is broken numerically (i.e., in the order of $M_1, M_2, \dots, M_6$). The value of a variable should be considered alphabetically (i.e., in the order of A, B, C). **[9 marks]**

(i) Write down the order of variables to be visited until finding a solution.

(ii) Write down the final solution (using the form of $(M_1, M_2, M_3, M_4, M_5, M_6) = (P_1, P_2, P_3, P_4, P_5, P_6), P_i \in \{A, B, C\}$).

(iii) Write down the undated domain of unassigned variables after the second variable is assigned during the search. You can give the intermediate assignments during the search so that you may still receive some marks even if your final answer is not accurate.

(d) Use **local search** to solve the problem. Suppose we start with a randomly generated assignment

$$(M_1, M_2, M_3, M_4, M_5, M_6) = (A, B, C, C, C, C), \tag{1}$$

meaning Professor A delivers M_1, Professor B delivers M_2, and Professor C delivers M_3, M_4, M_5 and M_6. Suppose we use the following rule for local update:

- At each step, always consider the variable which violates the most constraints. Let us assume that tie of variables is broken numerically (i.e., in the order of $M_1, M_2, \cdots$).
- After the variable to be considered is determined, choose the value in its domain that violates the fewest constraints. Let us assume the tie of values is broken alphabetically.

Please check whether this strategy of local search is able to find a solution from the given initial assignment. If yes, write down the assignment after each local update until finding a solution. If not, give your explanation. **[6 marks]**