CS 188 Fall 2024 Introduction to Artificial Intelligence Written HW2

Due: Tuesday 9/17 at 11:59pm.

Policy: Can be solved in groups (acknowledge collaborators) but must be submitted individually.

Make sure to show all your work and justify your answers.

Note: This is a typical exam-level question. On the exam, you would be under time pressure, and have to complete this question on your own. We strongly encourage you to first try this on your own to help you understand where you currently stand. Then feel free to have some discussion about the question with other students and/or staff, before independently writing up your solution.

Note: Leave the self-assessment sections blank for the original submission of your homework. After the homework deadline passes, we will release the solutions. At that time, you will review the solutions, self-assess your initial response, and complete the self-assessment sections below. The deadline for the self-assessment is 1 week after the original submission deadline.

Your submission on Gradescope should be a PDF that matches this template. Each page of the PDF should align with the corresponding page of the template (page 1 has name/collaborators, question begins on page 2.). **Do not reorder, split, combine, or add extra pages**. The intention is that you print out the template, write on the page in pen/pencil, and then scan or take pictures of the pages to make your submission. You may also fill out this template digitally (e.g. using a tablet.)

First name	
Last name	
SID	
Collaborators	

Q1. [20 pts] Secret Santa

The CS 188 staff members are playing Secret Santa! Each person brings a gift to the table, intending for a different person to receive that gift. However, past TA Albert, furious that he was not invited to participate, removes all the name cards on each gift so that none of the staff members know whose gift is whose!

The gifts are: AI textbook (A), Backgammon (B), Chess (C), Dinosaur toy (D), Easter egg (E), Flying drone (F) and Game of "Go" (G).

The participants are: Angela, Danial, Jonathan, Regina, Ryan, Saathvik, Yanlai
Angela and Regina are juniors and everybody else is a senior.

While the staff members have forgotten which gift is for who, Albert has left them some clues.

1. Each person should receive exactly one gift.
2. Any person whose name starts with R (Ryan, Regina) should not receive the AI textbook.
3. The Easter egg and Flying drone are for people of different grades.
4. The Flying drone and the Game of Go are for people of the same grade.
5. Any person whose name ends with a consonant (Danial, Jonathan, Ryan, Saathvik) should not receive the Chess set.

We frame this problem as a CSP, with the variable being a person, and the domain being the item they receive.

(a) **(i)** [2 pts] Given just these clues, we use **local search** to try to find a satisfying assignment. We'll initialize the assignments alphabetically (i.e. assign the i^{th} person in alphabetical order to the i^{th} gift in alphabetical order). Which of the variables are conflicted in this assignment?

☐ Angela ☐ Danial ■ Jonathan ☐ Regina ■ Ryan ■ Saathvik ☐ Yanlai ○ Nobody

Jonathan has been assigned the chess set (C), even though his name ends with a consonant. This conflicts with clue 5. Ryan and Saathvik are both seniors, but they are assigned the Easter egg and Flying drone, respectively. This conflicts with clue 3.

(ii) [2 pts] Because of the first clue, our iterative improvement strategy involves swapping the values of two variables. What is the minimum number of swaps needed for us to get an assignment that satisfies the above constraints?

○ 0 ○ 1 ● 2 ○ 3 ○ 4 ○ 5

(iii) [2 pts] Say we randomly choose to swap Ryan's value with someone else and use min-conflicts to decide who to swap with. Which of the people could be selected by the min-conflicts heuristic for Ryan to swap with?

☐ Angela ☐ Danial ☐ Jonathan ■ Regina ☐ Ryan ☐ Saathvik ☐ Yanlai ○ Nobody

Ryan would need to swap with a Junior (either Angela or Regina) to resolve his current conflict from clue 3. However, if Ryan swaps with Angela and receives the AI textbook (A), constraint 2 will now be violated. So, Ryan must swap with Regina.

Now Albert gives a few more clues:

6. One of Angela, Jonathan, Saathvik, or Yanlai should get Backgammon.
7. The person who should get Backgammon and the person who should get the Dinosaur have names with the same number of letters.
8. Regina's name contains the letter of the gift she should receive (i.e. A, E, or G).

(b) The TAs restart with all the variables unassigned, then enforce all unary constraints and perform arc consistency.

(i) [1 pt] Do we have enough information to fully deduce the value of any of the variables?

○ Yes ● No

Once we enforce unary constraints and arc consistency, Regina has the smallest remaining domain with 2 values (E and G). However, we still don't know which gift is hers.

(ii) [1 pt] How many values are left in Ryan's domain?

○ 1 ○ 2 ● 3 ○ 4 ○ 5 ○ 6 ○ 7

Given new clue 7, Ryan no longer has the same number of letters in his name (4) as any of the other TAs, so he can no longer receive the Dinosaur.

(iii) [2 pts] Using the MRV heuristic, which variable(s) could be assigned next? Select multiple if there's a tie.

☐ Angela ☐ Danial ☐ Jonathan ■ Regina ☐ Ryan ☐ Saathvik ☐ Yanlai ○ Nobody

How many values are in their domain?

○ 1 ● 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7

Regina has the smallest domain left out of all of the TAs – Regina can't receive the AI textbook (A) from clue 2, and clue 8 tell us that Regina can only be E or G.

(iv) [1 pt] Breaking ties alphabetically, we assign the first MRV variable then enforce arc consistency. Now, how many values are left in Angela's Domain?

○ 1 ○ 2 ○ 3 ● 4 ○ 5 ○ 6 ○ 7

After assigning Regina to E, let's evaluate the arc from Angela to Regina. By clue 1, Angela can no longer be assigned to E. By clue 3, Angela also can't be assigned to F because Regina and Angela are in the same grade (both juniors). Finally, by clue 4, Angela can no longer be assigned G, because Regina would have had to be assigned F.

Q1(a)-(b) Self-Assessment - leave this section blank for your original submission. We will release the solutions to this problem after the deadline for this assignment has passed. After reviewing the solutions for this problem, assess your initial response by checking one of the following options:

○ I fully solved the problem correctly, including fully correct logic and sufficient work (if applicable).

○ I got part or all of the question incorrect.

If you selected the second option, explain the mistake(s) you made and why your initial reasoning was incorrect (do not re-iterate the solution. Instead, reflect on the errors in your original submission). Approximately 2-3 sentences for *each* incorrect sub-question.

Albert now gives one last clue:

9. The Easter egg should go to a TA whose grade is a senior.

(c) We want to use this information to solve our CSP.
Hint: We may have to backtrack assignments from a previous part.

(i) [1 pt] Do we have enough information to fully deduce the value of any of the variables?

● Yes ○ No

(ii) [7 pts] Complete a full recursive backtracking search and identify a satisfying assignment. Apply the MRV heuristic when needed and break any ties alphabetically. Which gift does each person get?

Angela:	○ A	○ B	○ C	○ D	○ E	● F	○ G
Danial:	● A	○ B	○ C	○ D	○ E	○ F	○ G
Jonathan:	○ A	● B	○ C	○ D	○ E	○ F	○ G
Regina:	○ A	○ B	○ C	○ D	○ E	○ F	● G
Ryan:	○ A	○ B	○ C	○ D	● E	○ F	○ G
Saathvik:	○ A	○ B	○ C	● D	○ E	○ F	○ G
Yanlai:	○ A	○ B	● C	○ D	○ E	○ F	○ G

(iii) [1 pt] Which variable is assigned last in the backtracking search?

○ Angela ○ Danial ○ Jonathan ○ Regina ○ Ryan ○ Saathvik ● Yanlai

Once the new constraint is enforced, Regina is left with only one value in her domain (G). Once we make that assignment, we're able to assign the rest of the TAs in the following order: Angela, Ryan, Danial, Jonathan, Saathvik, Yanlai.

Remember that we break ties alphabetically in instances where multiple TAs have the same size domain.

Q1(c) Self-Assessment - leave this section blank for your original submission. We will release the solutions to this problem after the deadline for this assignment has passed. After reviewing the solutions for this problem, assess your initial response by checking one of the following options:

○ I fully solved the problem correctly, including fully correct logic and sufficient work (if applicable).

○ I got part or all of the question incorrect.

If you selected the second option, explain the mistake(s) you made and why your initial reasoning was incorrect (do not re-iterate the solution. Instead, reflect on the errors in your original submission). Approximately 2-3 sentences for *each* incorrect sub-question.