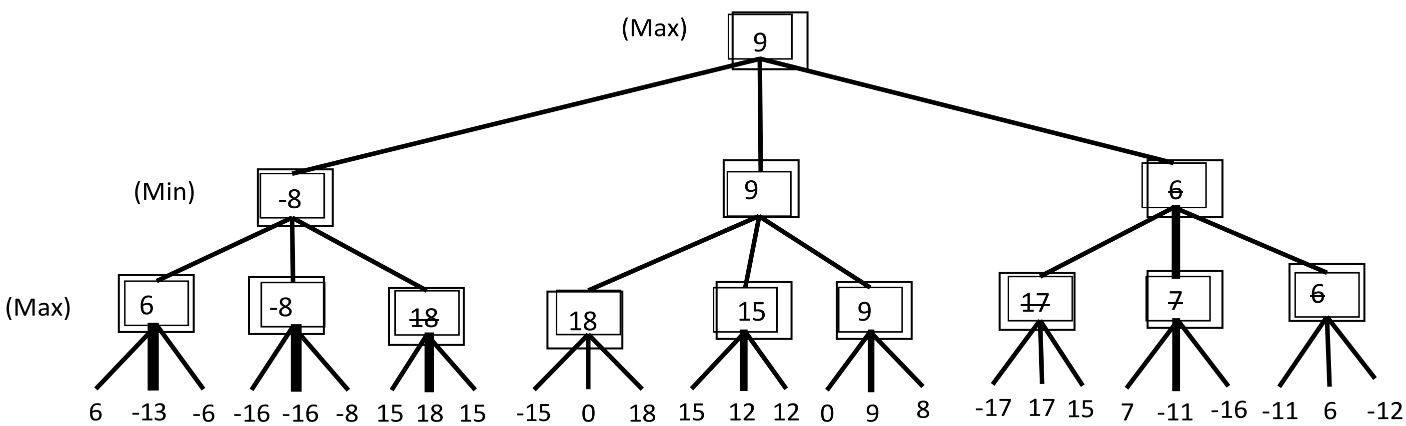
CSCE 580: Artificial Intelligence
Written Homework 2: Adversarial Search and Optimization
Due: 2/7/2024 at 11:58pm

You may either type your homework or upload a scanned copy of your written homework. However, your answers must be legible. **Answers that are not legible will be marked as incorrect.** Turn in a **PDF** (not Word or any other format) of your answers to Blackboard under Written HW/Written Homework 2.

1 Adversarial Search (30 pts)



1.1 Minimax Search (10 pts)

Fill in each square with the proper minimax value.

1.2 Alpha-Beta Pruning (20 pts)

Process the tree left-to-right. Cross out each **leaf** node that will be pruned by Alpha-Beta pruning.

2 Local Search (10 pts)

2.1 (2 pts)

Local search methods are guaranteed to find a global optimum in a finite amount of time. True or False?

2.2 (2 pts)

How can one build on hill-climbing search to handle getting stuck in local maxima?

If the search gets stuck, restart from a randomly generated state.

2.3 (2 pts)

Why is simulated annealing less likely to accept a bad move as the search progresses?

Simulated annealing is less likely to accept a bad move as the search progresses because more options will get eliminated.

2.4 (2 pts)

What is one potential benefit and one potential drawback of local beam search?

It can be better than running a bunch of independent searches. However, it could result in all states being concentrated in the same place, resulting in redundancies.

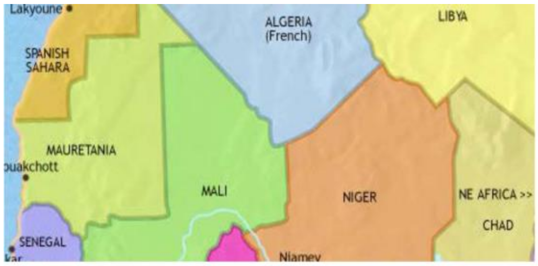
2.5 (2 pts)

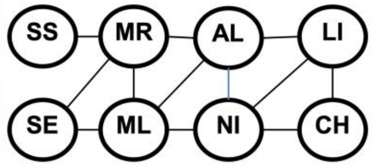
How does the manner in which crossover is done affect the efficacy of evolutionary algorithms?

The manner in which the crossover is done will affect the algorithm because it could potentially make the result better or worse.

3 Constraint Satisfaction: Map Coloring (30 pts)

pdf5





AL = Algeria
CH = Chad
LI = Libya
ML = Mali
MR = Mauretania
NI = Niger
SE = Senegal
SS = Spanish Sahara

You are a map-coloring robot assigned to color this map of west African countries. Adjacent regions must be colored a different color (R=Red, G=Green, B=Blue). The constraint graph is shown.

3.1 (5 pts)

NI has been assigned the value B, as shown; but no constraint propagation has been done. Cross out all values that would be eliminated by Forward Checking (FC):

AL	CH	LI	ML	MR	NI	SE	SS
R G ~~B~~	R G ~~B~~	R G ~~B~~	R G ~~B~~	R G B	B	R G B	R G B

3.2 (10 pts)

NI has been assigned B and AL has been assigned R, as shown; but no constraint propagation has been done. Cross out all values that would be eliminated by enforcing Arc Consistency.

AL	CH	LI	ML	MR	NI	SE	SS
R	R ~~G~~ ~~B~~	~~R~~ G ~~B~~	~~R~~ G ~~B~~	~~R~~ ~~G~~ B	B	R ~~G~~ ~~B~~	R G ~~B~~

3.3 (5 pts)

Consider the assignment below. NI has been assigned B and constraint propagation has been done, as shown. List all unassigned variables (in any order) that might be selected now by the Minimum-Remaining-Values (MRV) Heuristic: AL, CH, LI, ML

AL	CH	LI	ML	MR	NI	SE	SS
R G	R G	R G	R G	R G B	B	R G B	R G B

3.4 (5 pts)

Consider the assignment below. (It is the same assignment as in problem 3.3 above.) NI has been assigned B and constraint propagation has been done, as shown. Ignoring the MRV heuristic, list all unassigned variables (in any order) that might be selected now by the Degree Heuristic (DH): ML, AL, LI, CH, SE, MR, SS

AL	CH	LI	ML	MR	NI	SE	SS
R G	R G	R G	R G	R G B	B	R G B	R G B

3.5 (5 pts)

Consider the assignment below. (It is the same assignment as in problem 3.3 above.) NI has been assigned B and constraint propagation has been done, as shown. MR has been chosen as the next variable to explore. List all values for MR that could be explored first by the Least-Constraining-Value Heuristic (LCV). ML, AL, LI, CH, SE, MR, SS

AL	CH	LI	ML	MR	NI	SE	SS
R G	R G	R G	R G	R G B	B	R G B	R G B

4 Constraint Satisfaction: Class Scheduling (30 pts)

You are a scheduling robot assigned to schedule professors and computer science classes that meet M/W/F. There are 5 classes to schedule and 3 professors to teach these classes. Your requirements are: (1) each professor only teaches one class at a time; (2) each class is taught by only one professor; and (3) some professors can only teach some of the classes. You must produce a complete and consistent schedule.

You decide to formulate this task as a CSP in which classes are the variables (named C1 through C5) and professors are the domain values (named A, B, and C). After you have solved the CSP, each class (variable) will be assigned one professor (value), and all constraints will be satisfied.

The classes (variables) are:

- C1, Class 1 - Intro to Programming: meets from 8:00-8:50am
- C2, Class 2 - Intro to Artificial Intelligence: meets from 8:30-9:20am
- C3, Class 3 - Natural Language Processing: meets from 9:00-9:50am
- C4, Class 4 - Computer Vision: meets from 9:00-9:50am
- C5, Class 5 - Machine Learning: meets from 9:30-10:20am

The professors (domain values) are:

- A, Professor A, who is available to teach Classes C3 and C4.
- B, Professor B, who is available to teach Classes C2, C3, C4, and C5.
- C, Professor C, who is available to teach Classes C1, C2, C3, C4, C5.

4.1 (5 pts)

For each variable C1-C5 below, write down its domain as a subset of the values A, B, C. Enforce unary constraints as a preprocessing step, i.e., delete from the domain of each class variable any professor who is not available to teach that class.

C1 – C
C2 – B, ~~C~~
C3 – A, B, C
C4 – A, B, C
C5 – B, C

A – C3, C4
B – C2, C3, C4, C5
C – C1, C2, C3, C4, C5

4.2 (5 pts)

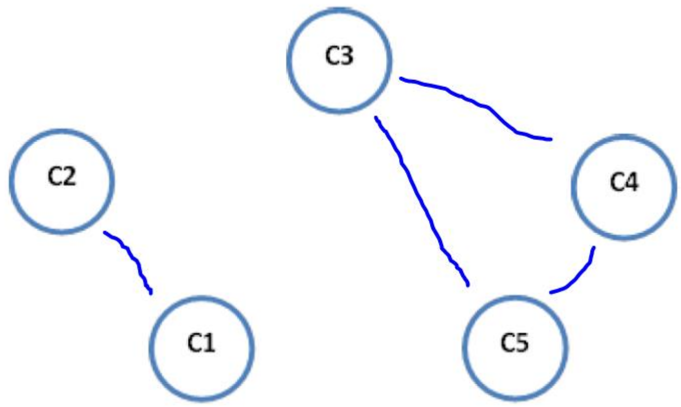
Write below all constraints that are associated with this CSP. Write each constraint implicitly as Ci = Cj for all classes Ci and Cj that overlap in time and so cannot be taught by the same professors

C1 = C2

C3 = C4 = C5

4.3 (5 pts)

Draw the constraint graph associated with your CSP. The nodes are provided for you. Draw the arcs.



4.4 (10 pts)

Run arc consistency (AC-3) on the domains in 4.1, the constrains in 4.2, and the constraint graph in 4.3. Write down the reduced domains that result when all inconsistent domain values are removed by AC-3.

C1 – C
C2 – B, ~~C~~
C3 – A, ~~B, C~~ ← Choose A
C4 – ~~A~~, B, ~~C~~ ← Choose B
C5 – ~~B~~, C

4.5 (5 pts)

Give one solution to this CSP. Remember that a solution is a complete assignment.

C1 = C

C2 = B

C3 = A

C4 = B

C5 = C