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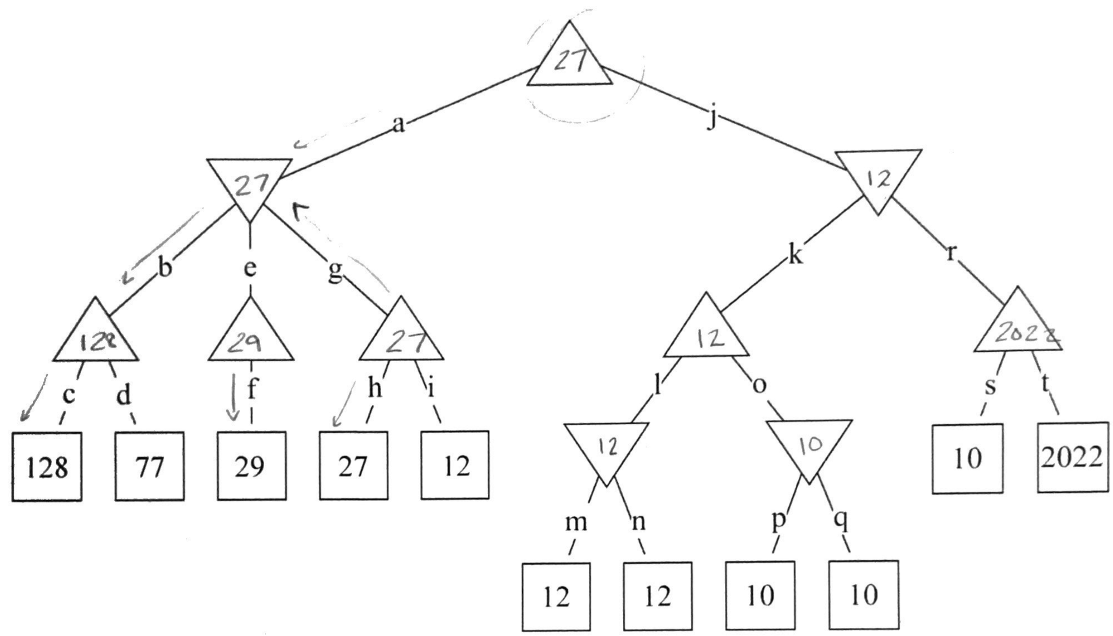
CS 4300 Homework 2 Prof. Alan Kuntz

Place your answers in the spaces provided, if you need more room write on the back of the pages. Round to two decimal places when rounding is required. ***SHOW ALL WORK.***

1 Adversarial Games



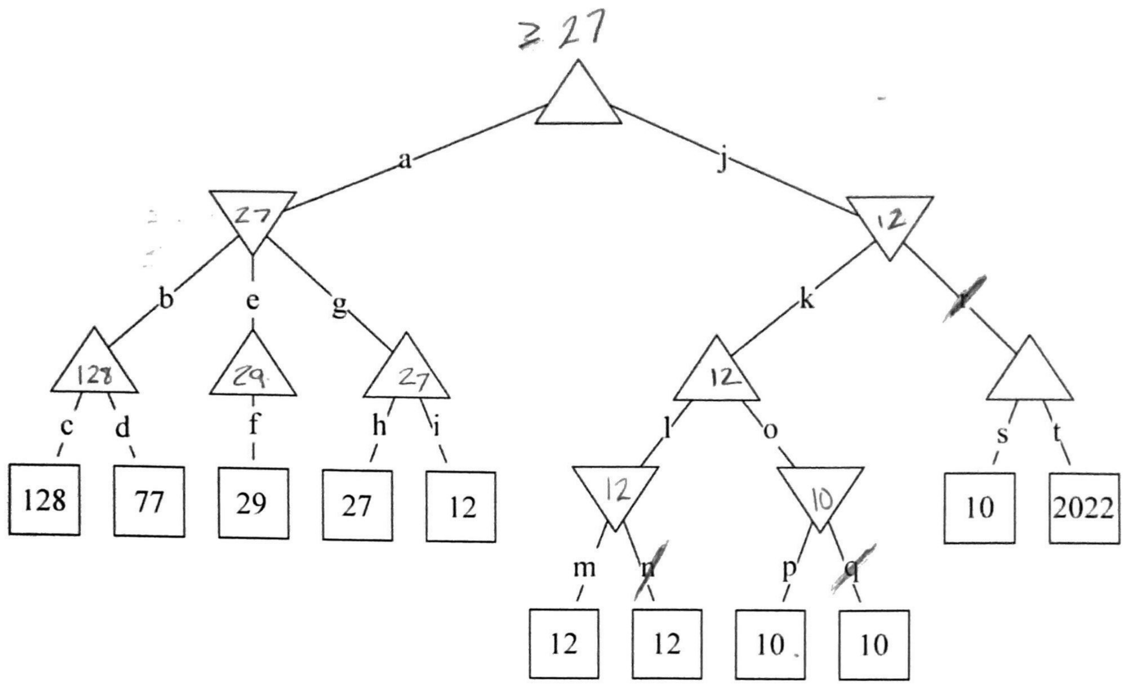
(a) Perform minimax search on the given tree. What value is returned (assigned to the root node)?

Answer: 27

(b) What path is selected by the minimax search you performed in the previous question? List the edges in the order in which the players would take them.

Answer: {a, g, h}

Name: UID:



(c) Perform alpha-beta pruning on the given tree. What edges are pruned?

You do not need to include an edge if it is the child of an edge that has already been pruned. For example, if **l** is pruned you do not need to list **m** or **n**.

This time, list the edges in alphabetical order. Traverse branches from left to right.

we prune the branches:

Answer: n, q, and r

Name:

UID:

2 Non-Zero-Sum Games

Alice is taking a class taught by Bob called "Artificial Intelligence." Bob has three ways he can teach the class: "Hard," "Medium" or "Easy." Alice has three effort levels she can take the class with: "High effort," "Medium effort" and "Low effort." For each of them, there are pros and cons. This gives rise to the following table of rewards. ***NOTE:*** These are written as (A, B) where A is Alice's reward and B is Bob's reward:

	Hard	**Medium**	**Easy**
High effort	$(15, 15)$	$(11, 9)$	$(0, 1)$
Medium effort	$(8, 10)$	$(9, 9)$	$(3, 1)$
Low effort	$(1, 0)$	$(5, 3)$	$(4, 4)$

Both Bob and Alice are trying to maximize their own rewards, both act optimally, and each has full knowledge of the others' reward tables and decisions.

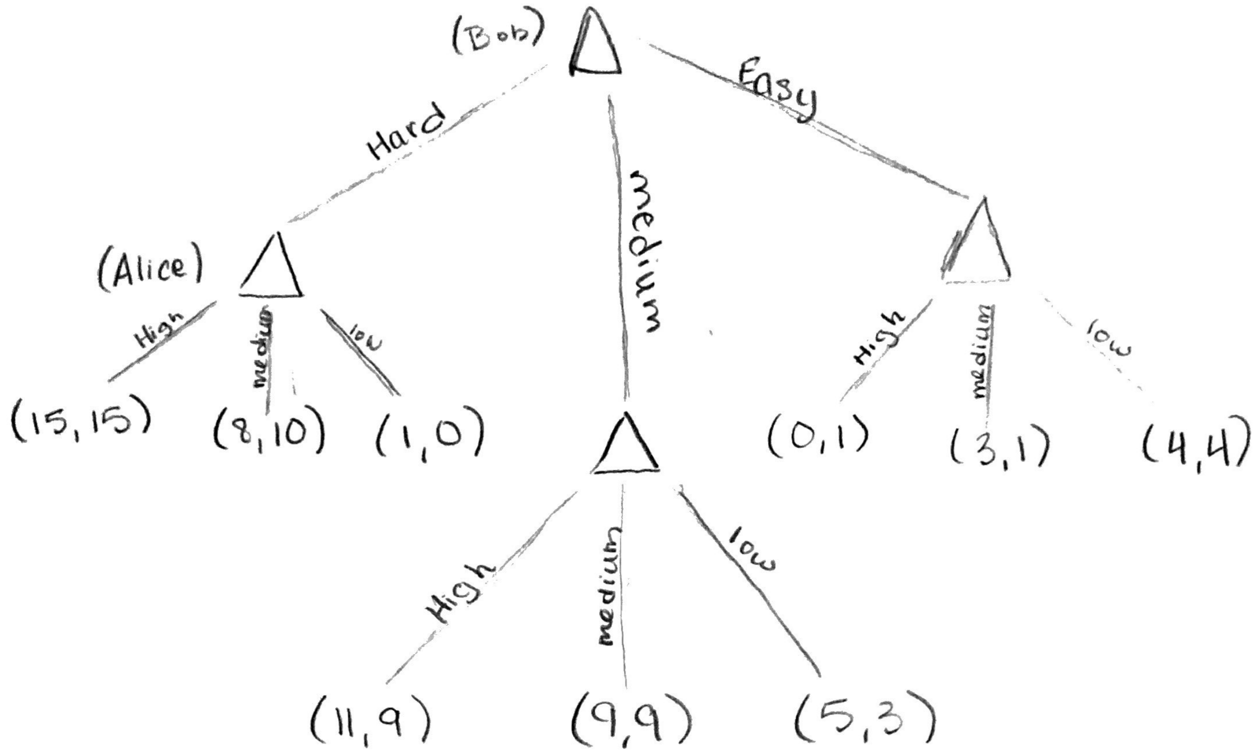
(a) If Bob decides how he should teach the course first, and then Alice decides how hard she should work, what should Bob's decision be? If Alice decides first and then Bob decides, what should Alice's decision be?

Knowing that both act optimally, if Bob decides first, he should teach "Hard" because that yields the best value for Bob. If Alice decides first, she should choose "High Effort" because that yields the best value for Alice.

Bob should choose "Hard" for 15
and

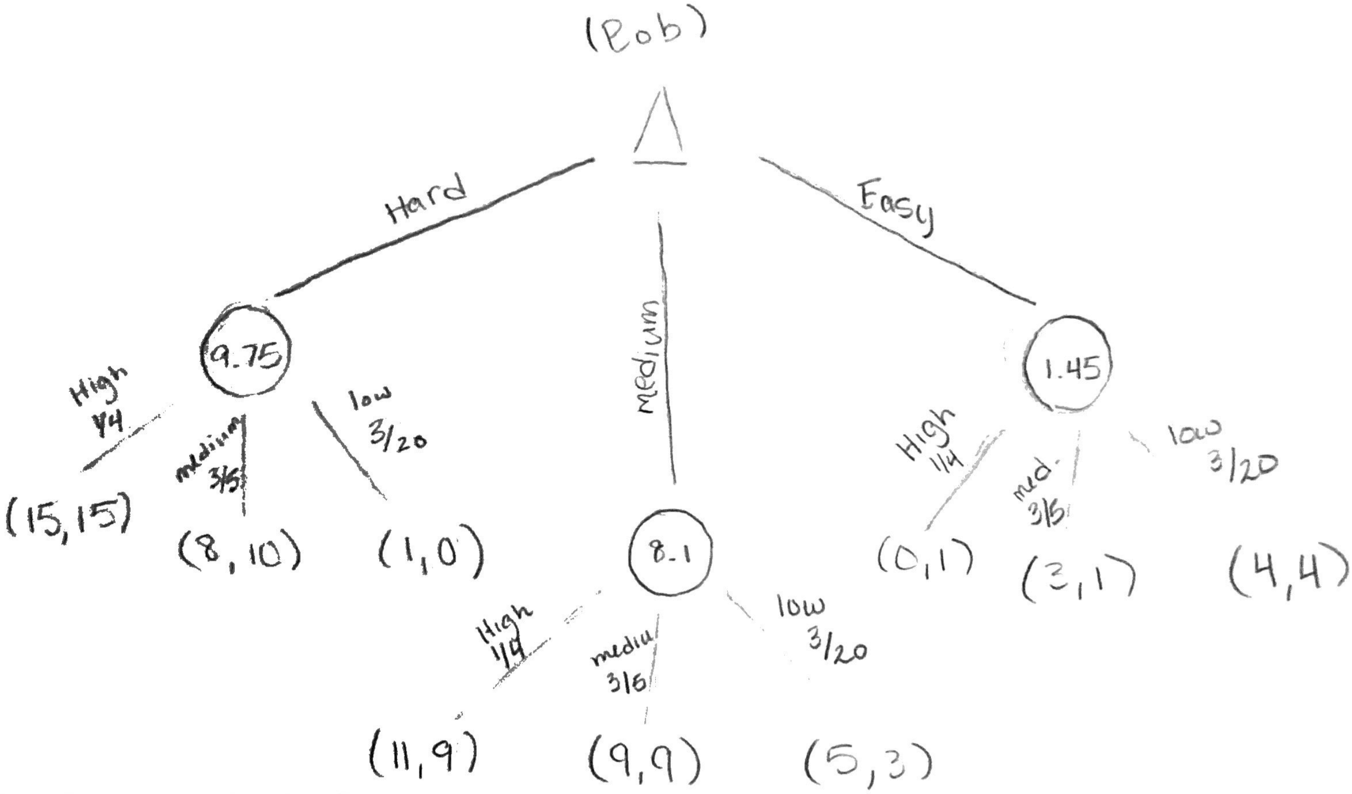
Answer: Alice should choose "High Effort" for 15.

(b) Draw a game tree for this problem supposing that Bob goes first. Propagate values up through the tree using (the non-zero-sum variant of) multi-agent search.



• Bob's best decisions are decided when Alice picks her best possible effort value.

(c) As there are more students than just Alice, it makes sense for Bob to model his class as a distribution over types of students. Suppose Bob believes that 25% of his class will put in high effort, 60% medium effort, and 15% will put in low effort. Draw the expectimax tree for this setting, concentrating only on Bob's reward, and compute expected node values. What is Bob's expected reward for this setting and which type of class should he teach?



Expected Hard: $(1/4)(15) + (3/5)(10) + (3/20)(0) = 39/4 \approx 9.75$

Expected Medium: $(1/4)(9) + (3/5)(9) + (3/20)(3) = 81/10 \approx 8.1$

Expected Easy: $(1/4)(1) + (3/5)(1) + (3/20)(4) = 29/20 \approx 1.45$

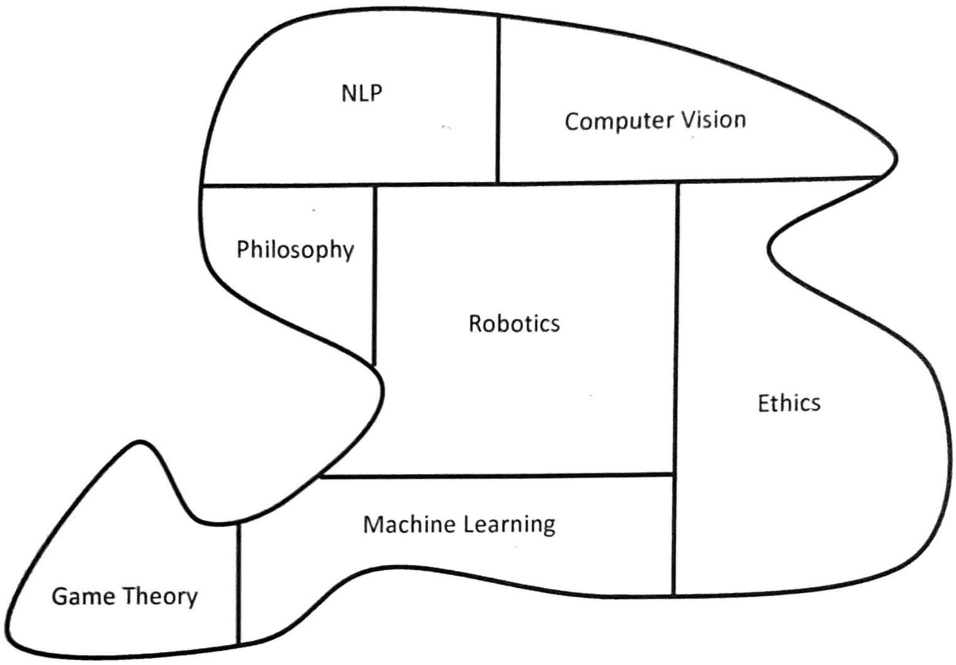
9.75 is the max value

Answer: Expected Reward: 9.75 and he should teach "Hard"

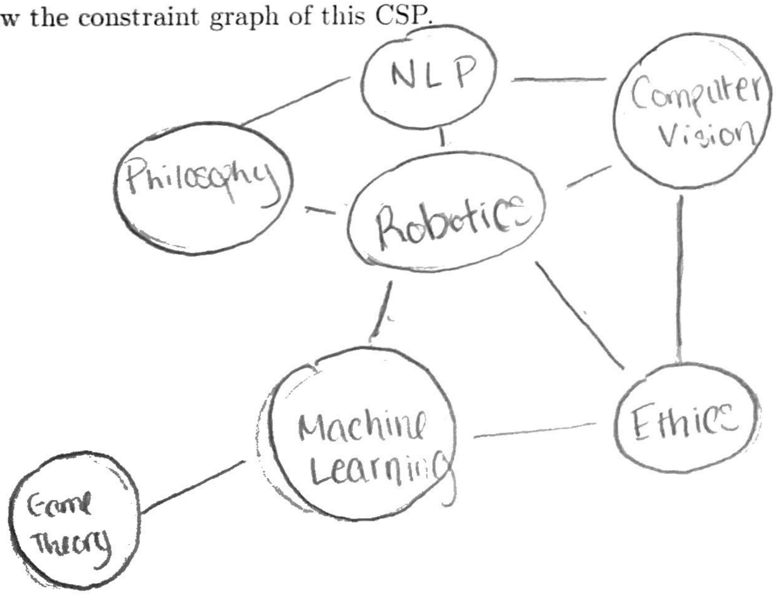
3 Constraint Satisfaction Problems

Consider the following map of AI Land, with the labeled territories. We need to color this map such that no two adjacent territories have the same color (as discussed at great length in class).

Map of AI Land



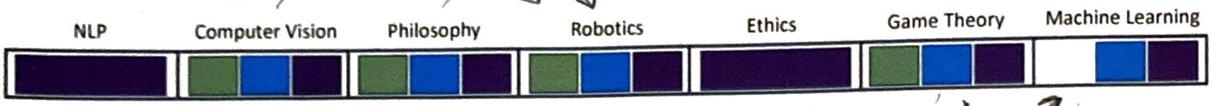
(a) Draw the constraint graph of this CSP.



(b) Make the following partial assignment arc-consistent (using the shown domains, which consist of combinations of purple, ~~green~~, and blue):

remove

remove tail



ML must be blue

delete purple on Comp Vision, Philos, & Robotics

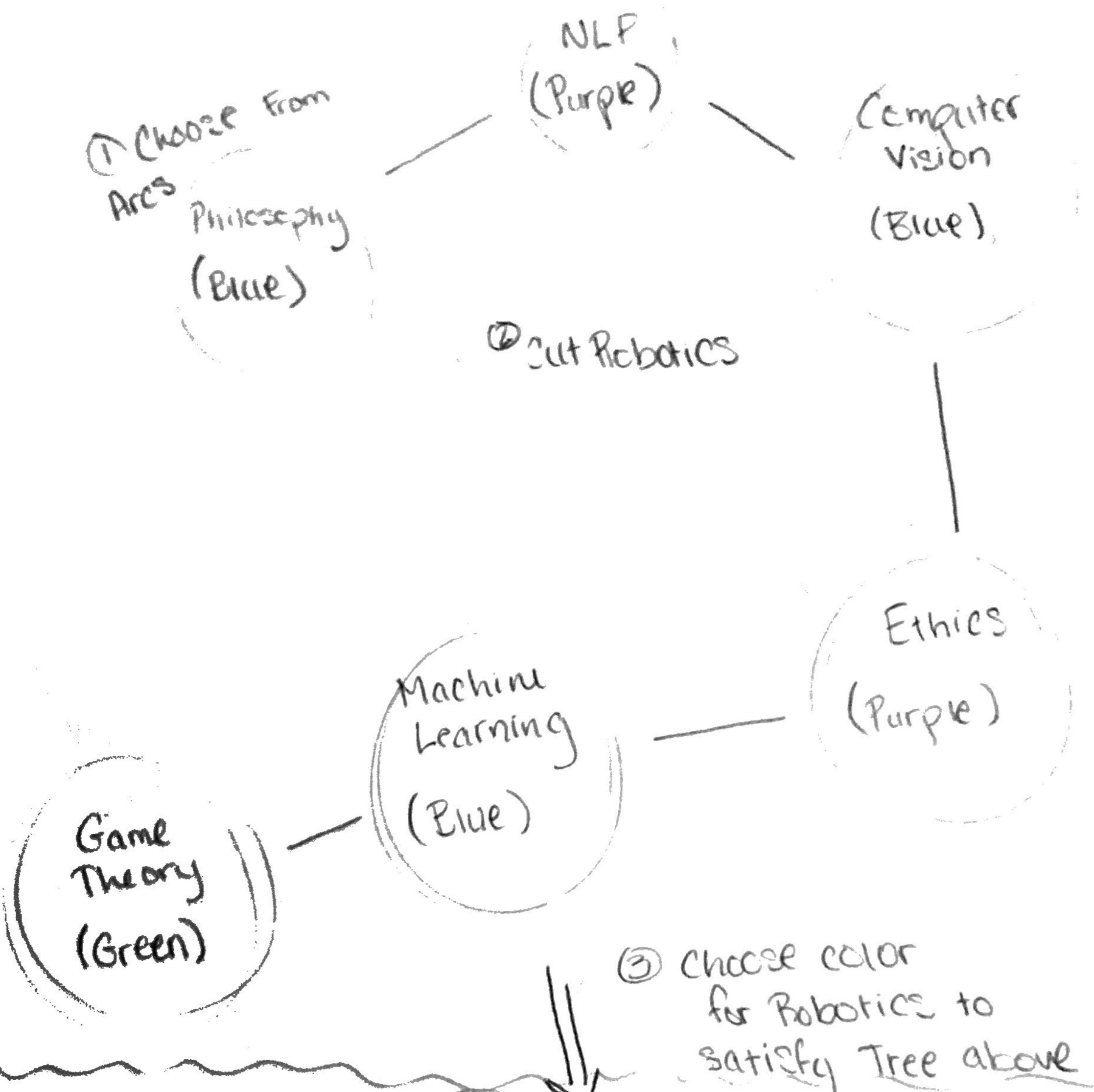
Iteration 1:

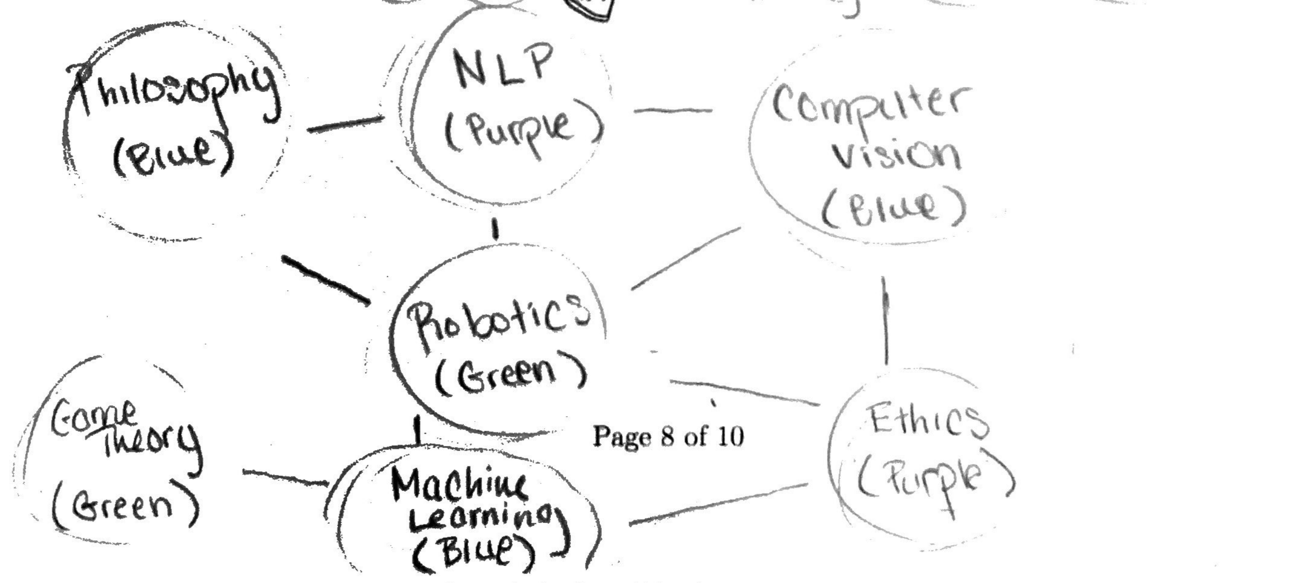
NLP	Comp Vis	Philoso	Robotics	Ethics	Game Theory	ML
Purple	~~G~~ B	~~G~~ B	G ~~B~~	Purple	G ~~B~~ P	Blue

Final:

NLP	Comp Vis	Philosophy	Robotics	Ethics	Game Theory	Machine Learning
Purple	Blue	Blue	Green	Purple	Green?Purple	Blue

(c) **Extra Credit**: Solve the initial unassigned CSP using purple, green, and blue as the domains *by leveraging cutset conditioning.*





4 Machine Learning

K-means clustering

Consider the K-means problem with 2 clusters. You are presented with the following six (x, y) data points:

(3.1, 3.7), (2.4, 3.1), (3.5, 3.1), (5.8, 5.05), (6.5, 5.2), (5.0, 6.0).

Using these two cluster means (i.e., centers) (3, 3) and (3, 4) to initialize your algorithm and using Euclidean distance for any distance calculation:

Perform 2 iterations of k-means updates *by hand* (using a calculator to help with the math is okay, using programming to implement k-means is not though) via the following steps:

(a) Given the initial cluster means above, assign each data point to the correct cluster.

(3.1, 3.7)

Distance to (3,3) $= \sqrt{(3.1-3)^2 + (3.7-3)^2} = \frac{\sqrt{2}}{2} \approx 0.71$

Distance to (3,4) $= \sqrt{(3.1-3)^2 + (3.7-4)^2} = \sqrt{10}/10 \approx 0.32$

$\Rightarrow$ Put (3.1, 3.7) in cluster (3,4)

(2.4, 3.1)

Dist to (3,3) $\approx$ 0.61

Dist to (3,4) $\approx$ 1.08

(3.5, 3.1)

Dist to (3,3) $\approx$ 0.51

Dist to (3,4) $\approx$ 1.03

(5.8, 5.05)

Dist to (3,3) $\approx$ 3.47

Dist to (3,4) $\approx$ 2.99

(6.5, 5.2)

Dist to (3,3) $\approx$ 4.13

Dist to (3,4) $\approx$ 3.7

(5.0, 6.0)

Dist to (3,3) $\approx$ 3.61

Dist to (3,4) $\approx$ 2.83

Answer: Cluster (3,3) : {(2.4, 3.1), (3.5, 3.1)}
Cluster (3,4) : {(3.1, 3.7), (5.8, 5.05), (6.5, 5.2), (5.0, 6.0)}

(b) Compute new cluster means.

Cluster (3,3) mean

- $x_{mean} = \frac{2.4 + 3.5}{2} = 2.95$
- $y_{mean} = \frac{3.1 + 3.1}{2} = 3.1$

Cluster (3,4) mean

- $x_{mean} = \frac{3.1 + 5.8 + 6.5 + 5.0}{4} = 5.1$
- $y_{mean} = \frac{3.7 + 5.05 + 5.2 + 6.0}{4} = 4.99$

Answer: Cluster (3,3) mean : (2.95, 3.1)
Cluster (3,4) mean : (5.1, 4.99)

(c) Compute new cluster membership based on the updated centers.

(3.1, 3.7)

Dist to (2.95, 3.1) ≈ 0.62

Dist to (5.1, 4.99) ≈ 2.38

(2.4, 3.1)

Dist to (2.95, 3.1) ≈ 0.55

Dist to (5.1, 4.99) ≈ 3.30

(3.5, 3.1)

Dist to (2.95, 3.1) ≈ 0.55

Dist to (5.1, 4.99) ≈ 2.48

(5.8, 5.05)

Dist to (2.95, 3.1) ≈ 3.45

Dist to (5.1, 4.99) ≈ 0.70

(6.5, 5.2)

Dist to (2.95, 3.1) ≈ 4.12

Dist to (5.1, 4.99) ≈ 1.42

(5.0, 6.0)

Dist to (2.95, 3.1) ≈ 3.55

Dist to (5.1, 4.99) ≈ 1.02

Cluster (2.95, 3.1): {(3.1, 3.7), (2.4, 3.1), (3.5, 3.1)}

Answer: Cluster (5.1, 4.99): {(5.8, 5.05), (6.5, 5.2), (5.0, 6.0)}

(d) Finally compute new cluster means.

Cluster (2.95, 3.1) mean

$x_{mean} = \frac{3.1 + 2.4 + 3.5}{3} = 3$

$y_{mean} = \frac{3.7 + 3.1 + 3.1}{3} = 3.3$

Cluster (5.1, 4.99 mean

$x_{mean} = \frac{5.8 + 6.5 + 5.0}{3} = 5.77$

$y_{mean} = \frac{5.05 + 5.2 + 6.0}{3} = 5.42$

Cluster (2.95, 3.1) mean: (3, 3.3)

Answer: Cluster (5.1, 4.99) mean: (5.77, 5.42)