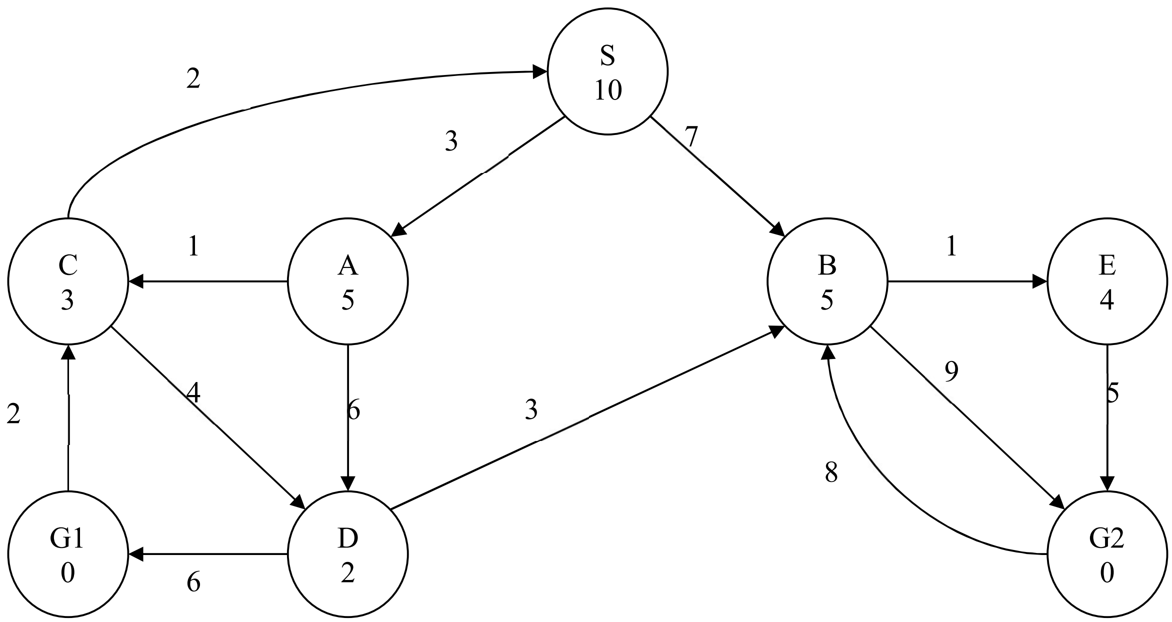
Introduction to AI: Homework
The theoretical part of the project

1– Search

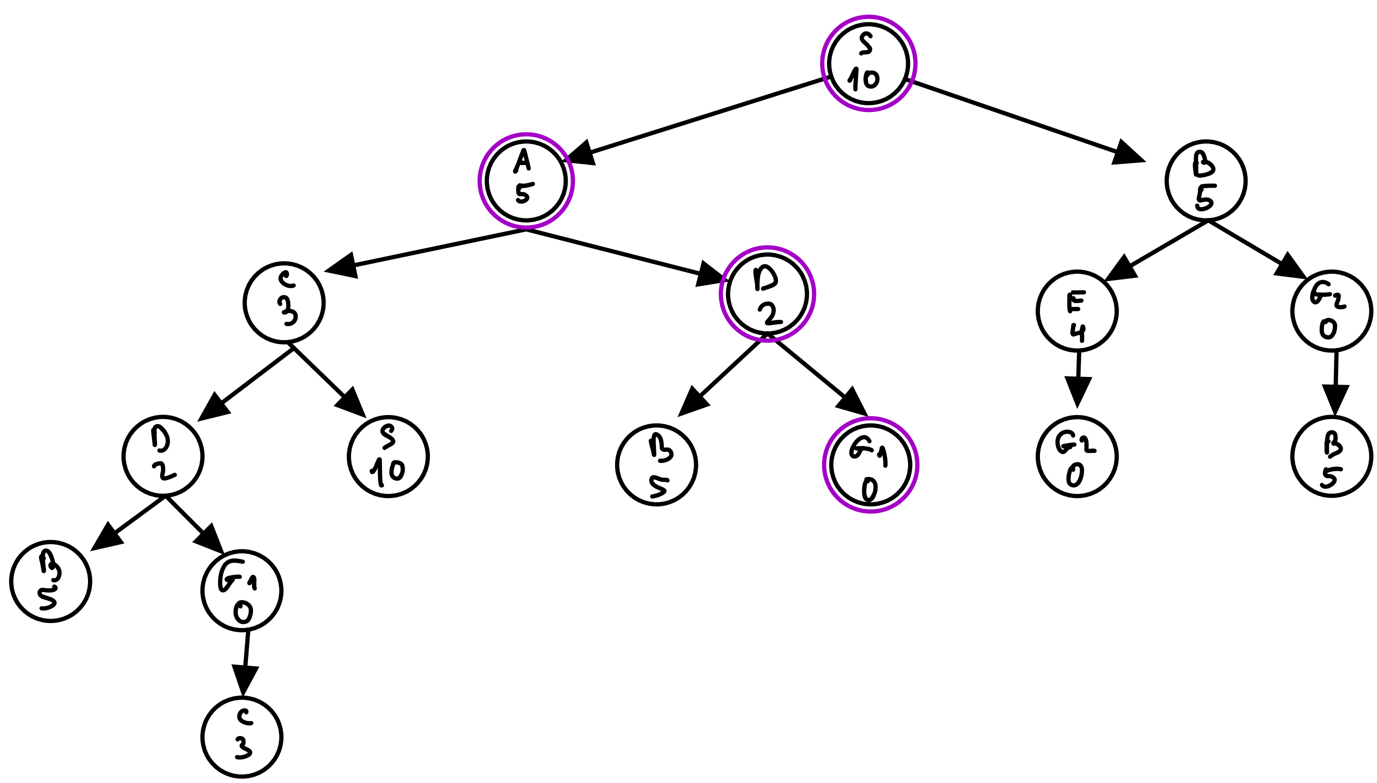
Given the search graph below, S is the initial node and G1, G2 are the target nodes. The edges between the nodes are indicated by the cost of the transition between the nodes. The estimated costs to the target notes are within the nodes.



For the hill climbing search algorithms, write the target node the algorithm arrives to (if any). In addition, write the order list of the nodes that are out of the open list. When there are equal parameters, the insertion to the open list is done by alphabetic order. Also, while sorting, nodes with equal values will be arranged in an alphabetic order.

According to the h-function only : Hill climbing

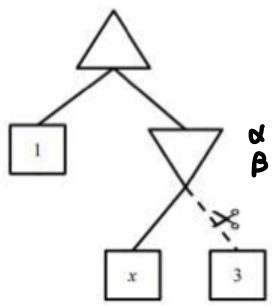
Target node: G1 , Nodes that are out of the open list: S, A, D, G1.



d.

2 – Game Playing

For each of the game-trees shown below, state for which values of x the dashed branch with the scissors will be pruned.
If the pruning will not happen for any value of x write "none".
If pruning will happen for all values of x write "all".
Otherwise, write a specific range of values. (E.g.: x≤7)

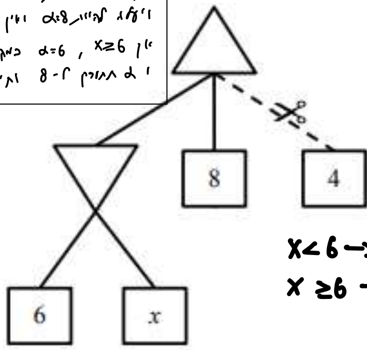


$\alpha = 1$
$\beta : \infty$

לאחר בדיקת מינימום מול β, β יקבל את הערך
אך בבדיקת המקסימום אותו 1 יושם ב-α בשורש העץ
לכן בשביל שיהיה גיזום של ענף עם 3 הערך של β
חייב להיות קטן שווה 1 כדי לעמוד ב-α,β pruning: $\alpha \geq \beta$

Tree 1: the answer is:
$X \leq 1$

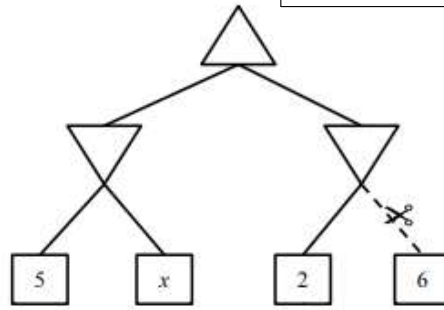
סתירה!
אם $x<6$ אז $\alpha<8$ ובמקרה המקסימום 8 ינצח
ויעלה להיות $\alpha=8$ ואין צורך בגיזום 4.
אם $x\ge 6$, $\alpha=6$ במקסימום ועד מול 8 הוא יפסיד
ו-α תהיה 8 ותגיע ל-4 כך שגם פה אין גיזום



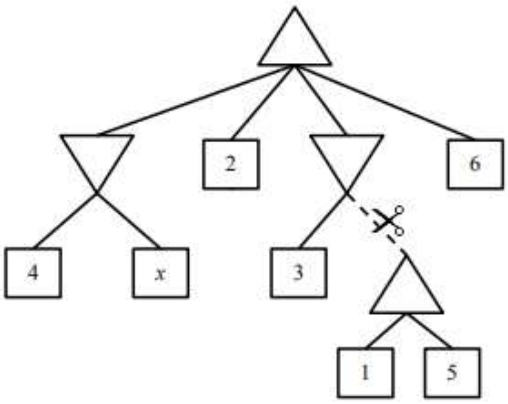
$x<6 \rightarrow \alpha<8$
$x\ge 6 \rightarrow \alpha=\infty$

Tree 2: the answer is:
none

אם $x\ge 2$ אז הערך של x יעלה ובסוף הערך יהיה α.
לאחר מכן β יהיה 2 ויתקיים הגיזום ו-6 יגזם
במצב ההפוך $x<2$ לא יתקיים התנאי ולא יהיה גיזום

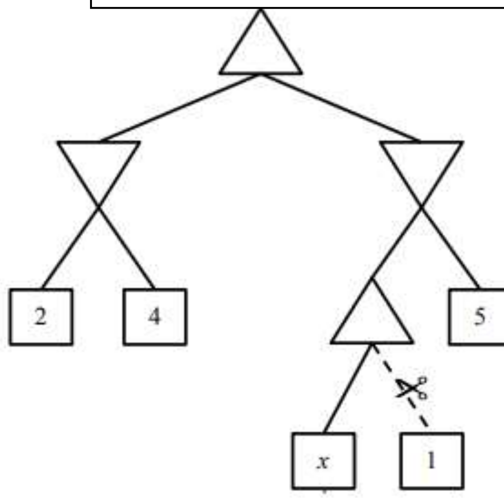


Tree 3: the answer is: $x\ge 2$



Tree 4: the answer is:
$x\ge 3$

אם $x<3$, α בראשית הענף תהיה ערך קטן שווה ל-2 ובמקסימום
מול 2 שורש הענף לא ישתנה.
בהמשך בבדיקה מול 3, ה-3 ינצח וימשיך לבדוק עם: 1-5



Tree 5: the answer is:
none

כל מצב! $x\le 2$ נבדוק מי גבוה יותר
1 מימין או x ולא משנה מי גבוה יותר
כי זה יגיע ל-β ומול זה $\alpha=2$ זה יעמוד
ב-$\alpha\ge\beta$ ואז 5 יגזם אך ב-$x>3$
בבדיקה מקס' מול 1, x ינצח ויגיע מול המין
ב-α וזה מוביל לכך שלא יהיה גיזומים

3-Decision Tree

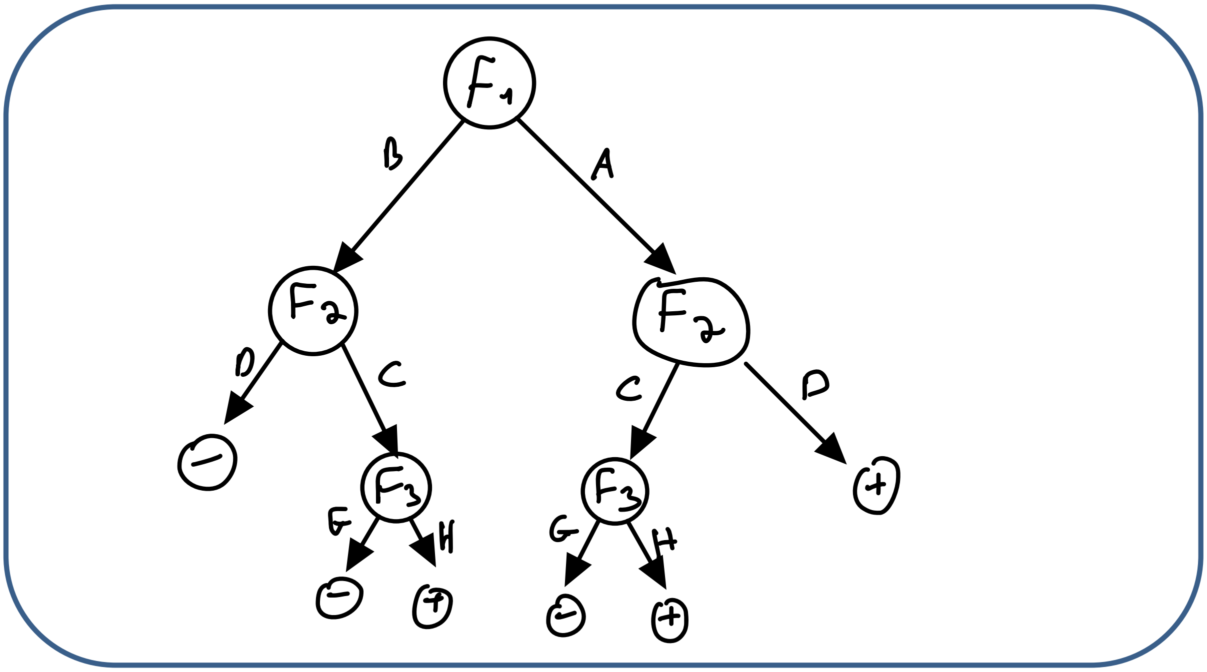
In order to build a DTL, the following examples were collected. Each example includes the values of three features: F1, F2, F3 and its category (+ or -).
The features' domains are {A,B}, {C, D} and {G,H} correspondingly.

$$\text{Entropy} = -\sum_{j=1}^{n} p_j \log_2 p_j$$

F1	F2	F3	Categ
A	C	H	+
A	D	G	+
A	C	G	-
A	D	G	+
B	D	H	-
B	D	H	-
B	C	H	+
B	C	G	-

Write the Decision Tree that will be built on these examples using the DTL algorithm and the GAIN theory.

Write all the details' calculations.



F_1: $H(catg|F_1) = p(F_1{:}A)\cdot H(catg|F_1{:}A) + p(F_1{:}B)\cdot H(catg|F_1{:}B)$

$p(F_1{:}A) = 0.5 \;,\; p(F_1{:}B) = 0.5$

$$\begin{cases} H(catg|F_1{:}A) = -\frac{1}{4}Log_2\frac{1}{4} - \frac{3}{4}Log_2\frac{3}{4} = 0.811 \\ H(catg|F_1{:}B) = -\frac{1}{4}Log_2\frac{1}{4} - \frac{3}{4}Log_2\frac{3}{4} = 0.811 \end{cases}$$

$H(catg|F_1) = 0.5\cdot 0.811 + 0.5\cdot 0.811 = 0.811$

* נבחר את ה IG הגבוה
ביותר שמעל ל אטריביוט הנמצא
ביותר הוא F_1 בשורש
העץ!

F_2: $p(F_2{:}C) = 0.5 \;,\; p(F_2{:}D) = 0.5$

$$\begin{cases} H(catg|F_2{:}C) = -\frac{1}{2}\log_2\frac{1}{2} - \frac{1}{2}\log_2\frac{1}{2} = 1 \\ H(catg|F_2{:}D) = -\frac{1}{2}\log_2\frac{1}{2} - \frac{1}{2}\log_2\frac{1}{2} = 1 \end{cases}$$

$H(catg|F_2) = 0.5\cdot 1 + 0.5\cdot 1 = 1$

F_3: $p(F_3{:}G) = 0.5 \;,\; p(F_3{:}H) = 0.5$

$$\begin{cases} H(catg|F_3{:}G) = -\frac{1}{2}\log_2\frac{1}{2} - \frac{1}{2}\log_2\frac{1}{2} = 1 \\ H(catg|F_3{:}H) = -\frac{1}{2}\log_2\frac{1}{2} - \frac{1}{2}\log_2\frac{1}{2} = 1 \end{cases}$$

$H(catg|F_3) = 0.5\cdot 1 + 0.5\cdot 1 = 1$

ככל שהאנטרופיה נמוכה יותר, כך החיזוי טוב יותר.

נמשיך ברמה 2 של העץ:

A

$$H(cats) = -\frac{1}{4}\log_2\frac{1}{4} - \frac{3}{4}\log_2\frac{3}{4} = 0.811$$

$$H(cats|f_2) = P(f_2=C)\cdot H(cats|f_2=C) + P(f_2=D)\cdot H(cats|f_2=D)$$

$$H(cats|f_2=C) = -\frac{1}{2}\log_2\frac{1}{2} - \frac{1}{2}\log_2\frac{1}{2} = 1$$

$$H(cats|f_2=D) = -1\log 1 = \underline{0} \quad \Rightarrow \quad H(cats|f_2) = \frac{1}{2}\cdot 1 + \frac{1}{2}\cdot 0 = \frac{1}{2}$$

$$H(cats|f_3=H) = -1\log 1 = \underline{0}$$

$$H(cats|f_3=G) = -\frac{1}{3}\log\frac{1}{3} - \frac{2}{3}\log\frac{2}{3} = 0.918 \Rightarrow H(cats|f_3) = \frac{3}{4}\cdot 0.918 + \frac{1}{4}\cdot 0 = 0.688$$

האנטרופיה של f_2 קטנה משל f_3 ולכן תיבחר ברמה 2 של העץ

בהמשך העץ אין צורך לבצע חלוקה נוספת מכיוון שרואים את החלוקה בבירור

B
- $f_1 = C \Rightarrow$ $H \to +$, $G \to -$
- $f_1 = D \Rightarrow$ $H \to -$, $H \to -$

A
- $f_2 = C \Rightarrow$ $G \to +$, $G \to +$
- $f_2 = D \Rightarrow$ $H \to +$, $G \to +$

4-Naïve Bayes

[redacted] **Naïve Bayes Classifier Learning.** You are a robot in an animal shelter, and must learn to discriminate Dogs from Cats. You choose to learn a Naïve Bayes classifier. You are given the following (noisy) examples:

Example	Sound	Fur	Color	Class
Example #1	Meow	Coarse	Brown	Dog
Example #2	Bark	Fine	Brown	Dog
Example #3	Bark	Coarse	Black	Dog
Example #4	Bark	Coarse	Black	Dog
Example #5	Meow	Fine	Brown	Cat
Example #6	Meow	Coarse	Black	Cat
Example #7	Bark	Fine	Black	Cat
Example #8	Meow	Fine	Brown	Cat

Consider a new example (Sound=Bark ^ Fur=Coarse ^ Color=Brown).
What will be the classification of this new example according to the Naïve Bayes Algorithm?
Please write all the calculations.

נחשב את כל ההסתברויות:

$p(Dog) = \frac{4}{8}$, $p(cat) = \frac{4}{8}$

$p(meow|Dog) = \frac{1}{4}$, $P(Bark|Dog) = 3/4$

$p(coarse|Dog) = \frac{3}{4}$, $p(fine|Dog) = 1/4$

$p(Brown|Dog) = \frac{2}{4}$, $p(Black|Dog) = 2/4$

$p(meow|cat) = \frac{3}{4}$, $p(bark|cat) = 1/4$

$p(coarse|cat) = 1/4$, $p(fine|cat) = 3/4$

$p(Brown|cat) = 1/2$, $p(Black|cat) = 1/2$

$p(bark, coarse, brown|Dog) = 0.75 \cdot 0.75 \cdot 0.5 \cdot 0.5 = 0.140$

$p(bark, coarse, brown|cat) = 0.5 \cdot 0.25 \cdot 0.25 \cdot 0.5 = 0.0156$

Its a dog!

5-BayesNet

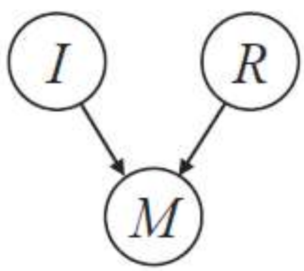
Mumps Outbreak There has been an outbreak of mumps at BIU. You feel fine, but you're worried that you might already be infected and therefore won't be healthy enough to take your CS 89-570 exam. You decide to use Bayes nets to analyse the probability that you've contracted the mumps.
You first think about the following two factors:

- random variable I: You think you have immunity from the mumps (+i) due to being vaccinated recently, but the vaccine is not completely effective, so you might not be immune (-i).
- random variable R: Your roommate didn't feel well yesterday, and though you aren't sure yet, you suspect they might have the mumps (+r)

Let the random variable M take the value +m if you have the mumps, and -m if you do not. You write down the following Bayes net to describe your chances of being sick:

I	$P(I)$
$+i$	0.8
$-i$	0.2

R	$P(R)$
$+r$	0.4
$-r$	0.6



I	R	M	$P(M\|I,R)$
$+i$	$+r$	$+m$	0
$+i$	$+r$	$-m$	1.0
$+i$	$-r$	$+m$	0
$+i$	$-r$	$-m$	1.0
$-i$	$+r$	$+m$	0.7
$-i$	$+r$	$-m$	0.3
$-i$	$-r$	$+m$	0.2
$-i$	$-r$	$-m$	0.8

- Fill in the missing values within the following table

I	R	M	$P(I,R,M)$
$+i$	$+r$	$+m$	0
$+i$	$+r$	$-m$	0.32
$+i$	$-r$	$+m$	0
$+i$	$-r$	$-m$	0.48
$-i$	$+r$	$+m$	0.056
$-i$	$+r$	$-m$	0.024
$-i$	$-r$	$+m$	0.024
$-i$	$-r$	$-m$	0.096

$p(+i) \cdot p(+r) \cdot p(m|I,r) = 0.8 \cdot 0.4 \cdot 1.0 = 0.32$

$p(+i) \cdot p(-r) \cdot p(m|I,r) = 0.8 \cdot 0.6 \cdot 1 = 0.48$

- Calculate the probability that he has mumps, i.e.: p(+m)

$p(+i,+r,+m) + p(+i,-r,+m) + p(-i,+r,+m) + p(-i,-r,+m)$

$0 + 0 + 0.056 + 0.024 = 0.08$

- Given you do have the mumps, you're concerned that your roommate may have the disease as well. What is the probability that your roommate has the mumps?
  Note that you still don't know whether or not you have immunity.

$\frac{p(r|m)}{p(m)} = \frac{0 + 0.056}{0.08} = 0.7$

GOOD LUCK!