Artificial Intelligence
Autumn 2018

COURSE: CS60045

Preparatory-1

1. The A* algorithm is based on…

(a) Breadth-First-Search

(b) Depth-First –Search

(c) Greedy Best-First-Search

(d) Hill climbing

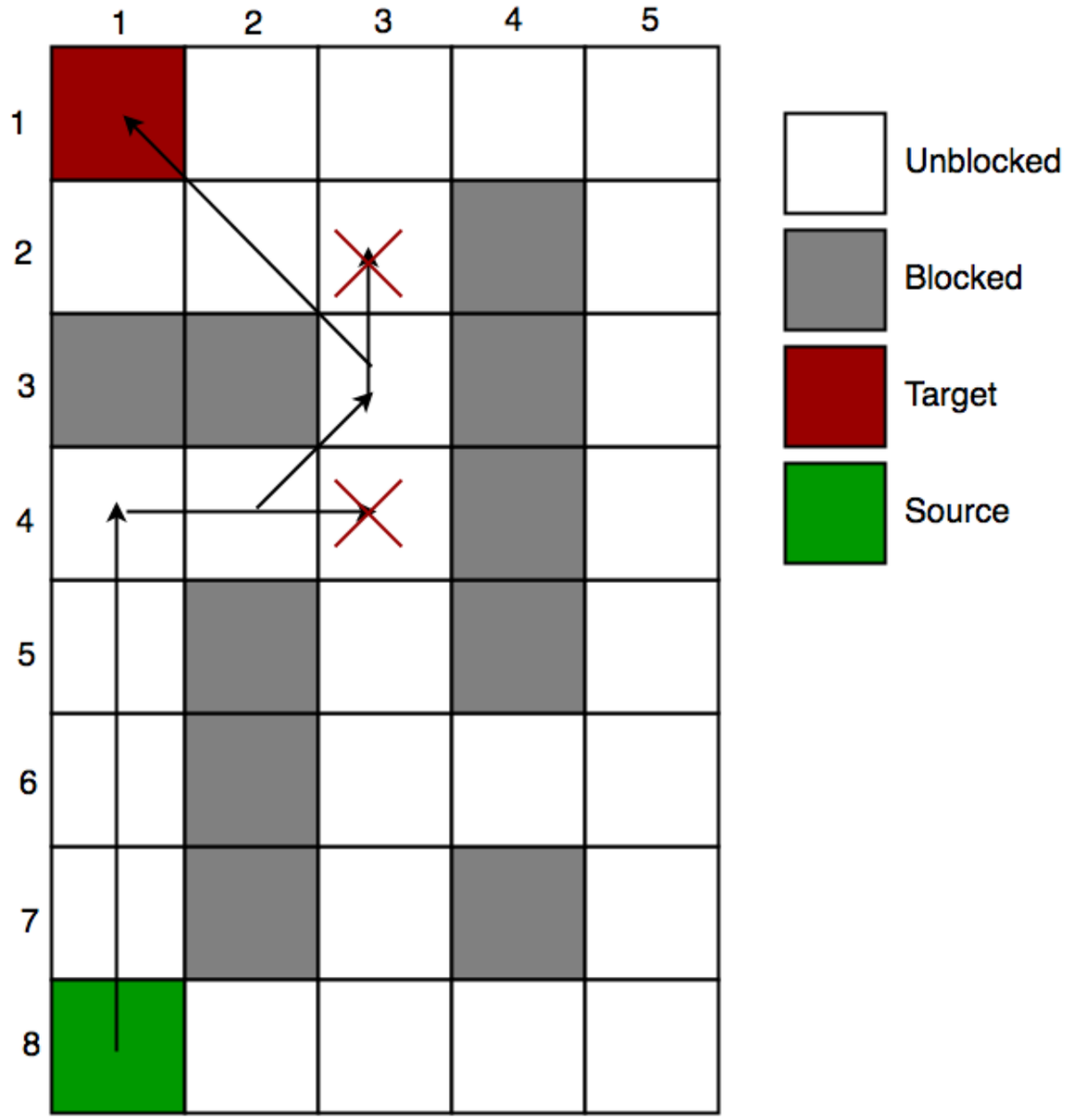
(e) Genetic Algorithm based Search

2. Which search is implemented with an initial FIFO queue?

(a) Depth First Search

(b) Breath First Search

(c) None-of-the-above



A robot must move from the source to the destination. The cost of moving:

"up or down" is 1,

"left and right" is 2,

"diagonally" is 2.

FORMULATE THE PROBLEM and SOLVE using

(a) Uniform Cost Search

(b) Branch & Bound

(c) A*

Heuristics?
Admissible?
Monotonic?

(d) IDA*

Heuristics for A*

Which of the following two heuristics is more informed?

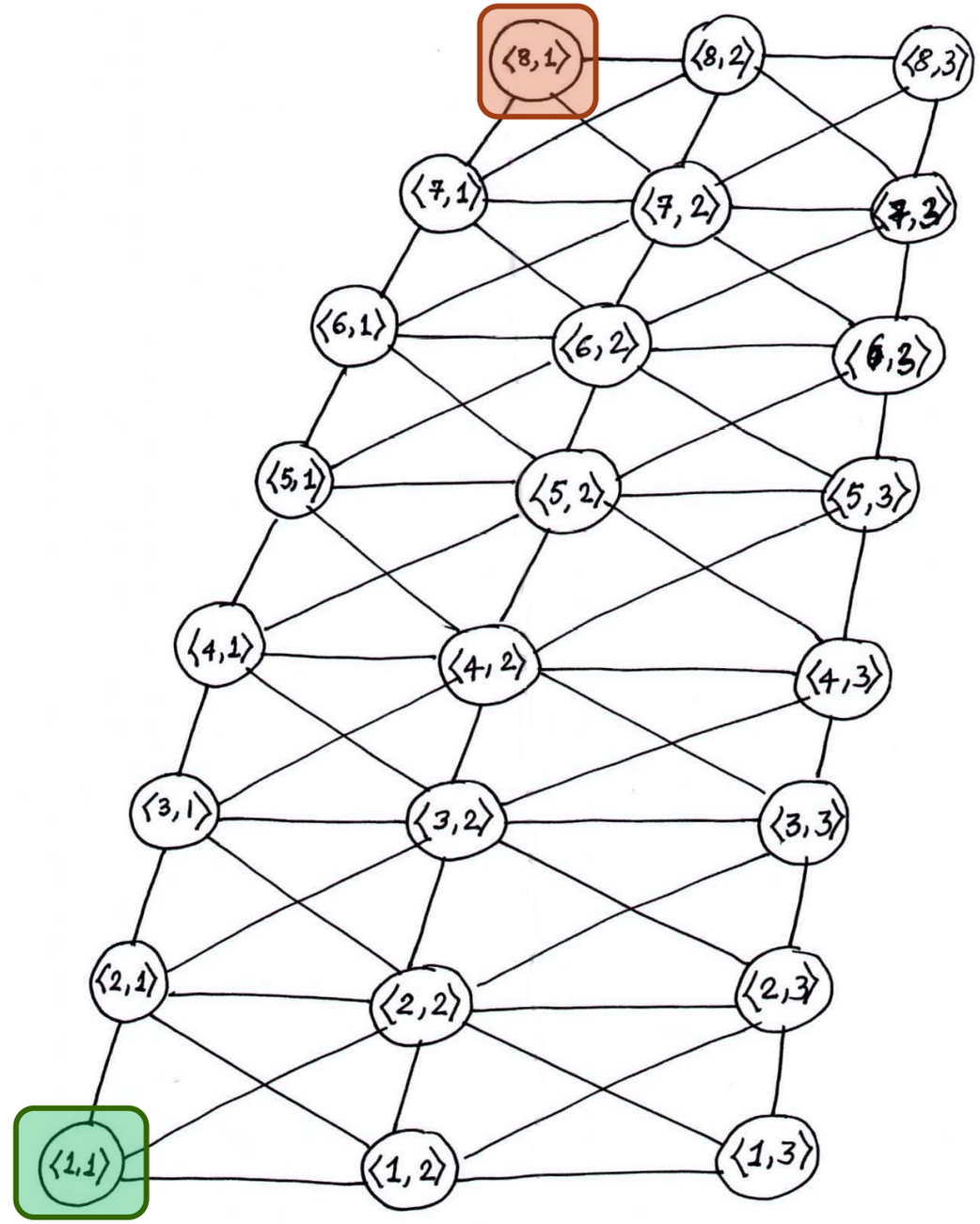
A. Manhattan Distance

B. Euclidean Distance

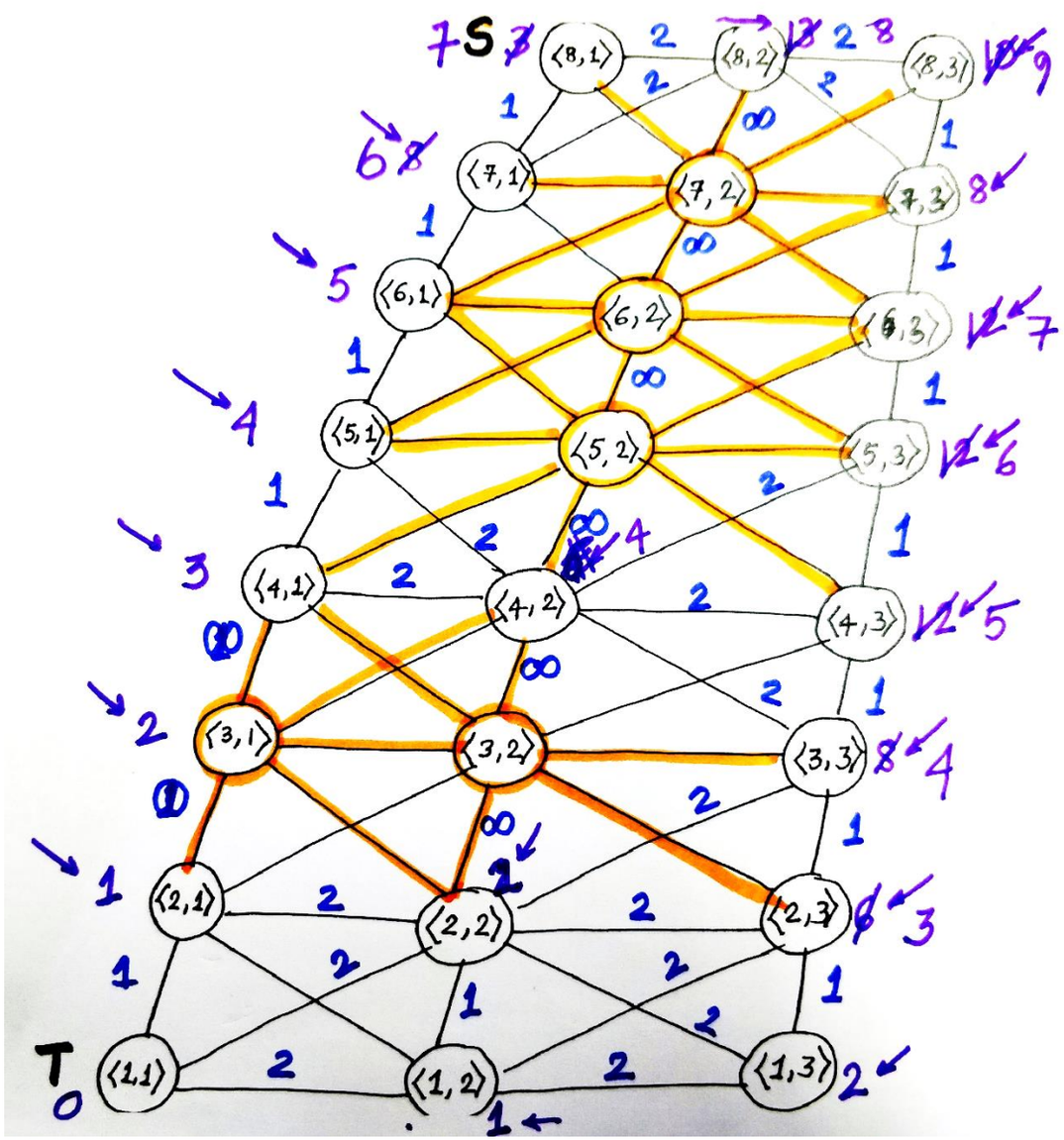
What about the following heuristic?

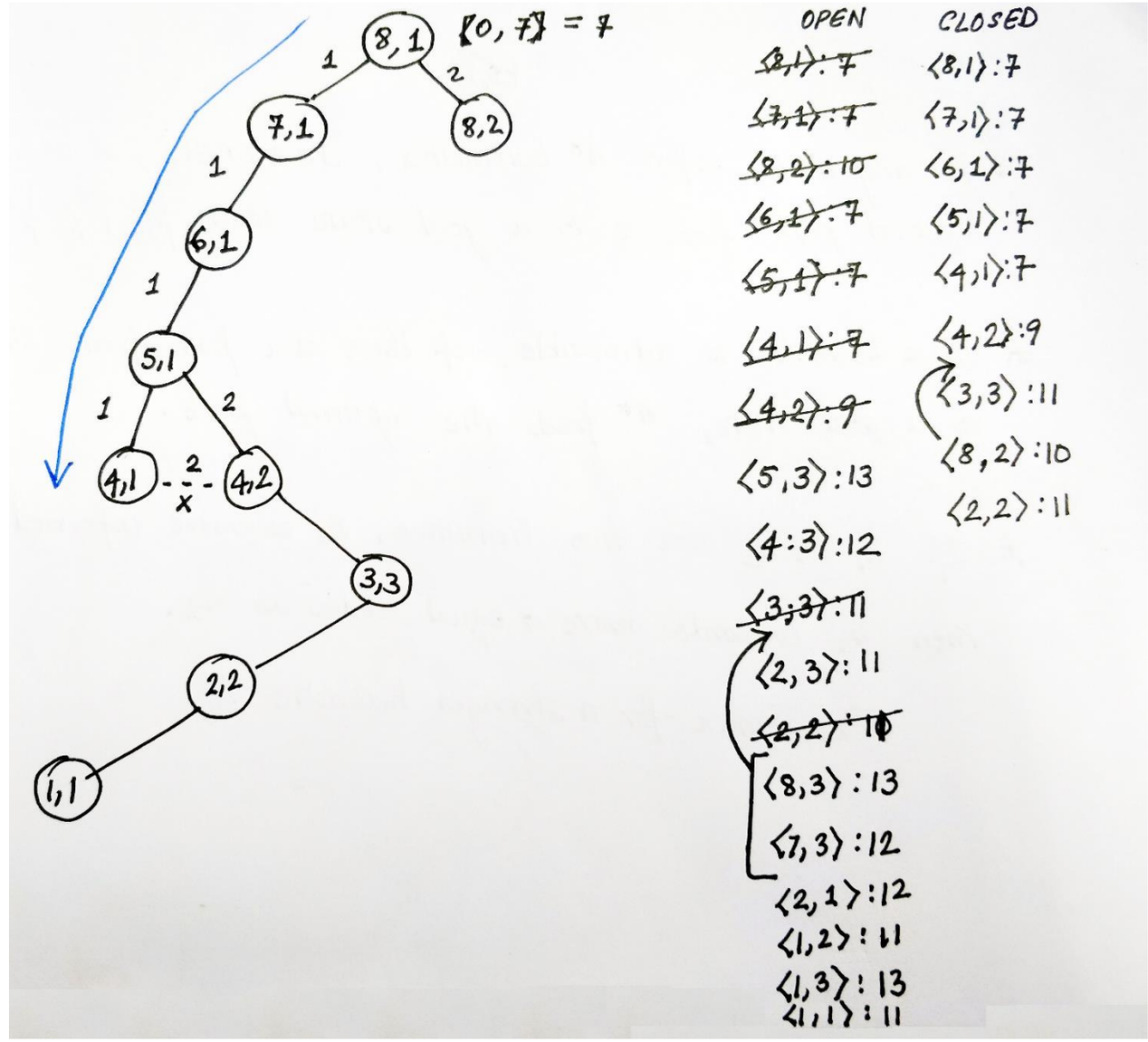
Manhattan Distance with a knowledge of Obstacles. (NO DIAGONAL MOVES)

Can you come up with a better heuristic?

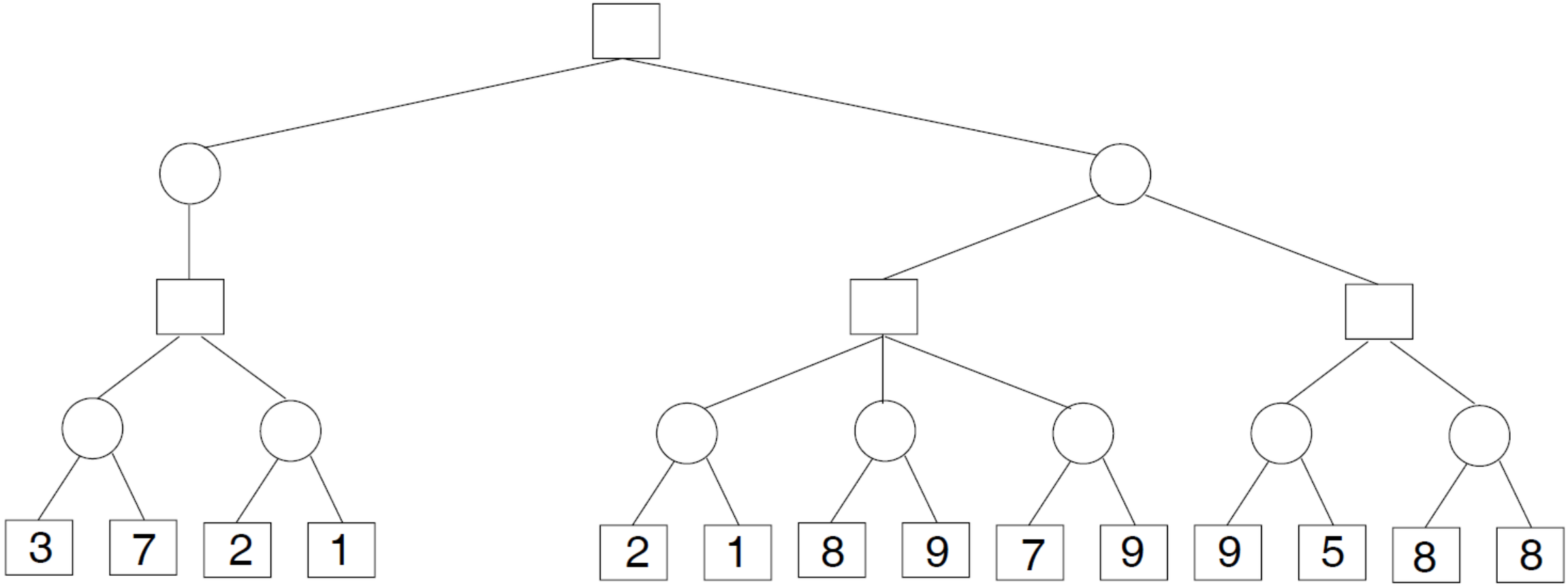


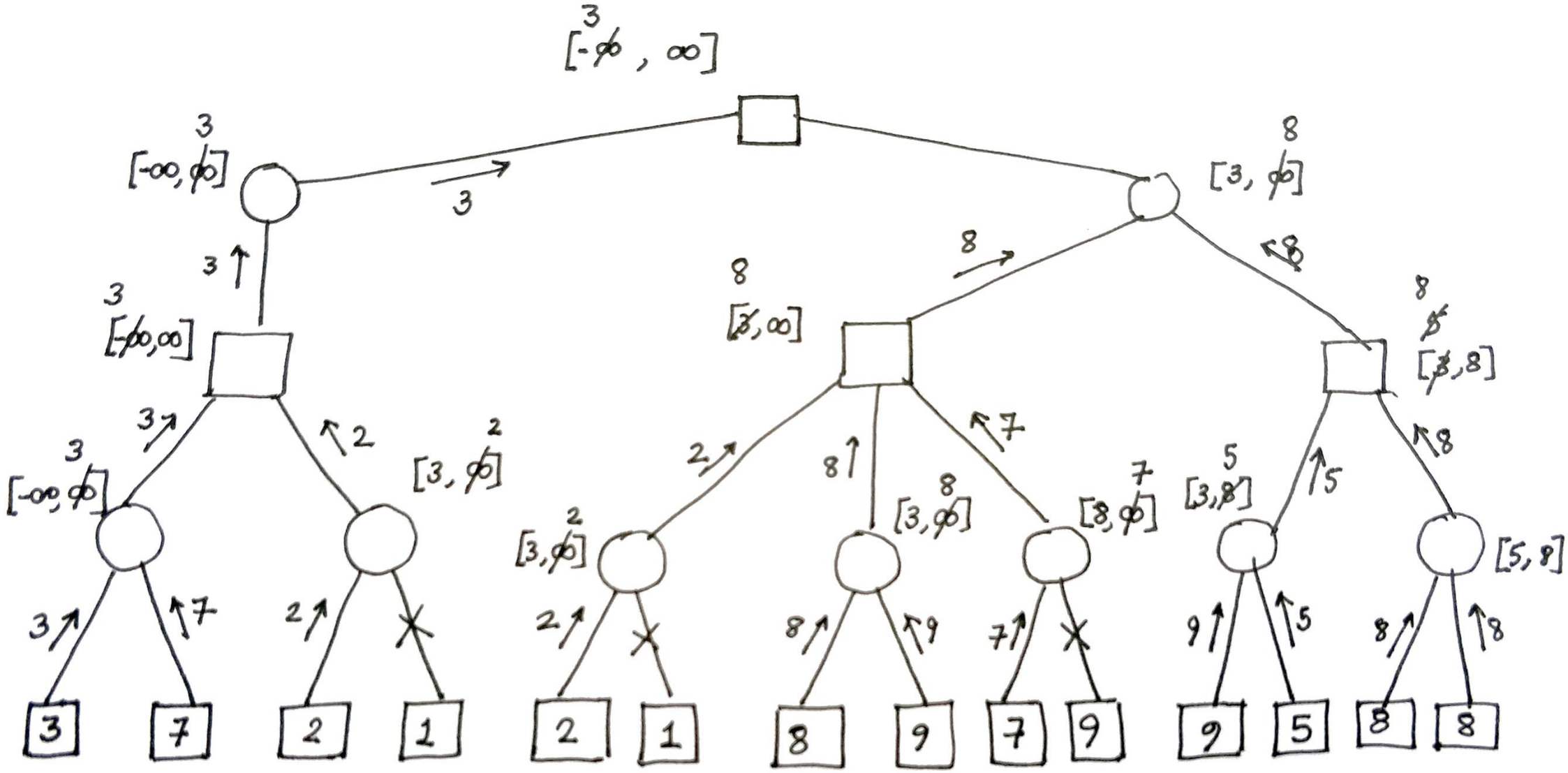
A* sample solution using the Manhattan Distance as a heuristic





Game Trees: Apply α-β Pruning on the following tree:




3
[-∞, ∞]
3
[-∞, ∞]
3
[-∞, ∞]
3
[-∞, ∞]
3
7
2
1
2
[3, ∞]
8
[3, ∞]
8
[∞, ∞]
2
[3, ∞]
2
1
8
[3, ∞]
8
9
7
[8, ∞]
7
9
8
[∞, 8]
5
[3, 8]
9
5
[5, 8]
8
8

Logic and Reasoning – Problem 1

Encode in First Order Logic:

(a) If a farmer owns a donkey he also owns a horse.

(b) The company has exactly one CEO.

(c) Somebody has won a million euros. Anyone who has won a million euros is rich. Therefore there is someone who is rich.

(d) No ducks are willing to waltz. No officers are unwilling to waltz. All my poultry are ducks. Therefore, none of my poultry are officers.

Sample Solutions for Problem 1

a) farmer(x)
owns(x,y)
donkey(x)
horse(x)

$\forall x \exists y \quad (farmer(x) \wedge donkey(y) \wedge owns(x,y)) \Rightarrow (\exists z \; horse(z) \wedge owns(x,z))$

b) company(x)
ceo(x,y)

$\forall x \; company(x) \Rightarrow \exists y \; ceo(x,y) \wedge (\forall z \; ceo(x,z) \Rightarrow z = y)$

c) person(x)
wonAMillion(x)
rich(x)

$\left(\wedge \begin{array}{l} (\exists x \; person(x) \wedge wonAMillion(x)) \\ (\forall y \; WonAMillion(y) \Rightarrow rich(y)) \end{array} \right) \Rightarrow \exists z \; rich(z)$

d) duck(x)
waltz(x)
officer(x)
poultry(x)

$\forall x \; duck(x) \Rightarrow \neg waltz(x)$ OR $\neg(\exists x \; duck(x) \wedge waltz(x))$

$\wedge \quad \neg \exists y \; (officer(y) \wedge \neg waltz(y))$

$\wedge \quad \forall x \; poultry(x) \Rightarrow duck(x)$

$\therefore \forall x \; poultry(x) \Rightarrow \neg officer(x)$

Logic and Reasoning – Problem 2

You are walking in a labyrinth and all of a sudden you find yourself in front of three possible roads: the road on your left is paved with gold, the one in front of you is paved with marble, while the one on your right is made of small stones. Each street is protected by a guardian. You talk to the guardians and this is what they tell you:

- **The guardian of the gold street: "This road will bring you straight to the centre. Moreover, if the stones take you to the centre, then also the marble takes you to the centre."**
- **The guardian of the marble street: "Neither the gold nor the stones will take you to the centre."**
- **The guardian of the stone street: "Follow the gold and you'll reach the centre, follow the marble and you will be lost."**

Given that you know that all the guardians are liars, can you choose a road being sure that it will lead you to the centre of the labyrinth? If this is the case, which road you choose?

Provide a *propositional* language and a set of axioms that formalize the problem and show whether you can choose a road being sure it will lead to the center.

Sample Solutions for Problem 2

Problem 2

gg : guardian of the gold street is telling the truth

gm : " —— " marble " —— "

gs : " —— " stone " —— "

g : The gold road leads to the centre

m : " marble " —— "

s : " stone " —— "

$gg \Leftrightarrow [g \wedge (s \Rightarrow m)]$

$gm \Leftrightarrow (\neg g \wedge \neg s)$

$gs \Leftrightarrow (g \wedge \neg m)$

$\neg gg \wedge \neg gm \wedge \neg gs$

$\neg(g \wedge (\neg s \vee m)) \equiv \neg g \vee (s \wedge \neg m) \equiv (\neg g \vee s) \wedge (\neg g \vee \neg m)$

$\neg(\neg g \wedge \neg s) \equiv g \vee s$

$\neg(g \wedge \neg m) \equiv \neg g \vee m$

g	s	m	$[\neg g \vee (s \wedge \neg m)]$	$[g \vee s]$	$[\neg g \vee m]$	$\wedge \equiv \neg S_1 \wedge \neg S_2 \wedge \neg S_3$
0	0	0	1	0	1	0
0	0	1	1	0	1	0
0	1	0	1	1	1	1
0	1	1	1	1	1	1
1	0	0	0	1	0	0
1	0	1	0	1	1	0
1	1	0	1	1	0	0
1	1	1	0	1	1	0

Logic and Reasoning – Problem 3

Express the following knowledge K as a set of first-order logic formulas:

- **There are exactly three people in a club, Arijit, Sonam and Tapsee**
- **Arijit and Tapsee are married (not necessarily to each other)**
- **If a member of the club is married, then his/her spouse is also in the club**

Now add enough common sense statements (for example, everyone has at most one spouse, nobody can be married to himself or herself, Arijit, Sonam and Tapsee are different people) to make K entail a formula expressing the fact that "Sonam is not married". Show this by means of a resolution-refutation proof.