CSGA 6525 Artificial Intelligence

Fall 2017

Midterm Exam

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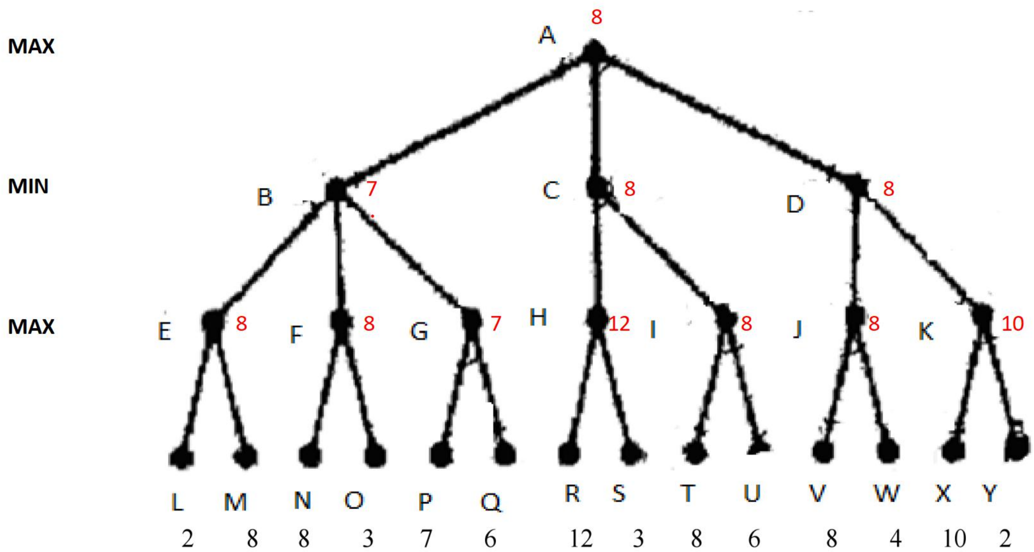
Q1.

Depth first iterative deepening search works by looking for the best search depth d. In our case, we started with limit depth 0 and visited root node, 1. Then we increase depth limit by 1 and conduct DFS: visited root node 1 and its child nodes:4, 3, 2 from left to right. Then we increase depth limit by 2 and conduct DFS: visited root node 1, 4, 9, 8, 3, 7, 2, 6, 5 respectively. Here we can see the difference compared to DFS: even 8 has two leaf nodes, we **won't act like DFS** at this time to go further to explore the two leaf nodes 13,12 because the limit is 2. We just stay in the depth where we are. Then we repeat increase depth limit and conduct DFS...the nodes in order that we visited for our case should listed as below:

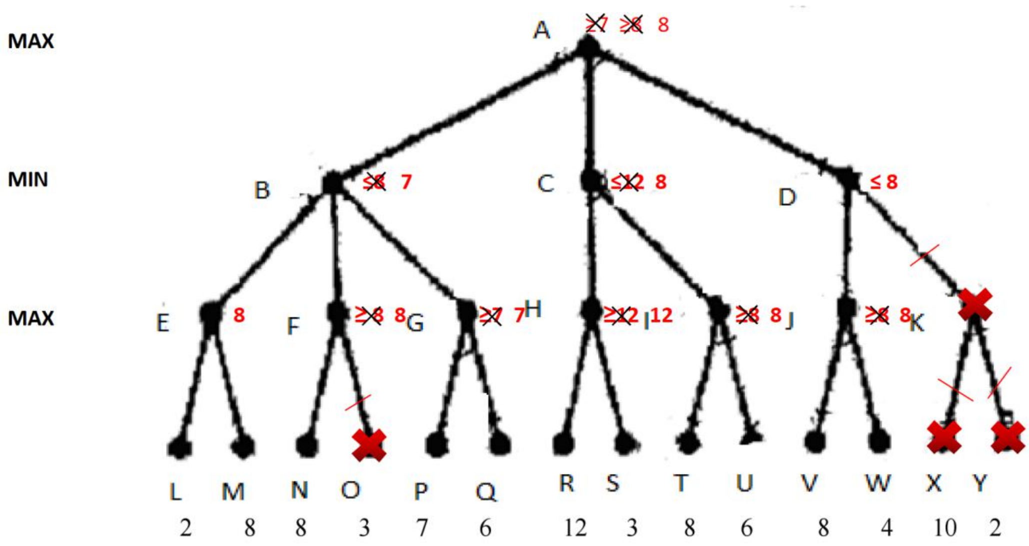
Limit	Nodes visited in order
0	1
1	1, 4, 3, 2
2	1, 4, 9, 8, 3, 7, 2, 6, 5
3	1, 4, 9, 8, 13, 12, 3, 7, 11, 10, 2, 6, 5

Q2

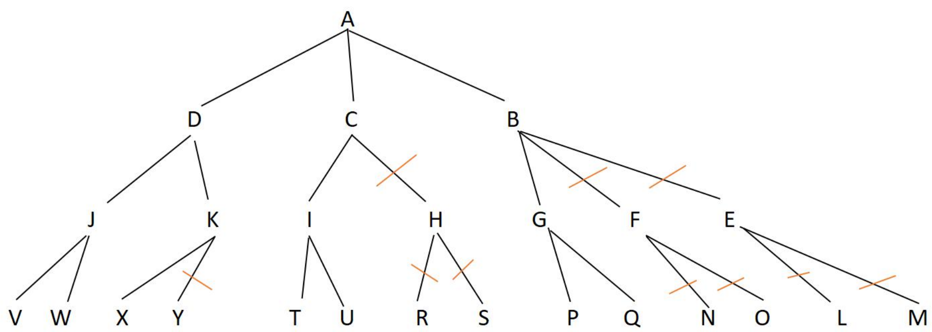
(a) & (b)



(c) Nodes are not expanded: O, K, X, Y



(d) The order for successor nodes that produces the best savings with alpha-beta search:



Q3

(a)

Propositional logic has very limited expressive power, while FOL is expressive; Propositional logic assumes the world contains facts, while FOL assumes the world contains objects, relations and functions.

For **example**: we want to declare that Audrey Hepburn is beautiful. In propositional logic, it should be: 'Audrey Hepburn is beautiful'. In FOL, it should be: beautiful(Audrey Hepburn). Both cases are OK.

But if we want to express that all actresses are beautiful, in propositional logic, it should be like: 'Audrey Hepburn is an actress⇒Audrey hepburn is beautiful', 'Jennifer Lawrence is an actress⇒Jennifer Lawrence is beautiful'... until we list all actresses in the world. But in FOL, we can simply say that: $\forall a \quad Actress(a) \Rightarrow Beautiful(a)$.

(b)Explaination:

Someone is never ever fooled by any politicians.

(c)

“Sometimes people are fooled by politicians”:

$\exists$ p,q,t p pol(p) $\wedge$ person(q) $\wedge$ time(t) $\wedge$fools(p,q,t)

Where politician(p) is true if p is a politician, person(q) s true if q is a person, time(t) is true if t is time and fools(p,q,t) is true if p fools person q at time t.

Q4

(a)Entailment by model-checking: enumerating models and showing that the sentence must hold in all models. That is, to check α is true in all worlds where KB is true/M(KB) $\subseteq$ M(α).

Entailment by inference: Applying inference rules, we directly generate new sentences from our knowledge base until we get the desired sentence. The proof is a sequence of inference rule applications and we don't need to consult models.

(b)check if KB is **CNF**/conjunctive normal form:if it is not, we need to change it to CNF **because** the resolution algorithm needs to be performed with disjunctions of literals clauses

Then, to show that KB|= α, we need to prove that **KB$\wedge\neg\alpha$** is **unsatisfiable**. **Why?**

According to the deduction theorem, For any sentences α and β, α |= β if and only if the sentence ($\alpha \Rightarrow \beta$) is valid. In our case: KB |= α if and only if the sentence (KB $\Rightarrow \alpha$) is valid.

We know that a sentence is valid if it is true in all models. We also know that validity and satisfiability are connected: to prove that (KB $\Rightarrow \alpha$) is valid, we can prove that (KB $\Rightarrow \alpha$) is valid iff $\neg$(KB $\Rightarrow \alpha$) is unsatisfiable.

Now, we can check standard logical equivalences. From the rule 'contraposition', we can prove that(KB $\Rightarrow \alpha$) $\equiv$ ($\neg$KB $\vee$ α).

According to the 'De Morgan' rule, ($\neg$KB $\vee$ α) $\equiv\neg$(KB $\wedge$ $\neg\alpha$)

Therefore: (KB $\Rightarrow \alpha$) $\equiv\neg$(KB $\wedge$ $\neg\alpha$); $\neg$(KB $\Rightarrow \alpha$) $\equiv\neg$($\neg$(KB $\wedge$ $\neg\alpha$)); $\neg$(KB $\Rightarrow \alpha$) $\equiv$ (KB $\wedge$ $\neg\alpha$)

Therefore, by showing (KB $\wedge$ $\neg\alpha$) is unsatisifiable, we can prove that $\neg$(KB $\Rightarrow \alpha$) is unsatisfiable; Then we can prove that (KB $\Rightarrow \alpha$) is valid and that KB|= α.

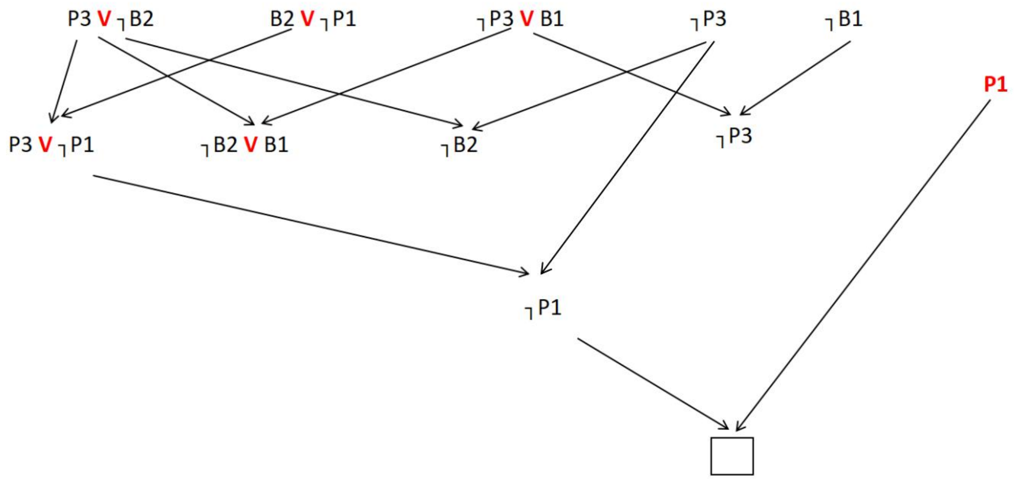
So, in order to show that KB|= α, we need to prove that KB$\wedge\neg\alpha$ is unsatisfiable.

(c)Resolution:

Because the KB is a conjunctive normal form, CNF, the resolution inference rule for CNF could be for example:

$$\frac{A \vee B,\ \text{not } A \vee C}{B \vee C}$$

In order to prove that KB$\models$ α, we need prove that KB$\wedge\neg\alpha$ is unsatisfiable, that is, to prove KB$\wedge\neg$($\neg$P1) is unsatisfiable:



From the plot above, we can conclude that $KB \wedge \neg\alpha$ is unsatisfiable.
Therefore, $KB \models \alpha$.