CS360 – Homework #3

Resolution with Propositional Logic

1) When asked for the ages of her three children, Mrs. Baker says that Alice is her youngest child if Bill is not her youngest child, and that Alice is not her youngest child if Carl is not her youngest child. Write down a knowledge base that describes this riddle and the necessary background knowledge that only one of the three children can be her youngest child. Show with resolution that Bill is her youngest child.

Let the propositions A, B and C denote that Mrs. Baker's youngest child is Alice, Bill and Carl, respectively. We have the following clauses for the background knowledge:

1 $A \vee B \vee C$ (One child has to be the youngest.)

2 $\neg A \vee \neg B$ (Alice and Bill cannot both be the youngest.)

3 $\neg A \vee \neg C$

4 $\neg B \vee \neg C$

The following clauses represent the information from Mrs. Baker:

5 $B \vee A$ (Alice is her youngest child if Bill is not her youngest child. That is, $\neg B \Rightarrow A$.)

6 $C \vee \neg A$ (Alice is not her youngest child if Carl is not her youngest child. That is, $\neg C \Rightarrow \neg A$.)

We want to show that Bill is the youngest child. Negating this, we get the following clause:

7 $\neg B$ (Assume that Bill is not the youngest child.)

We use resolution to derive the empty clause as follows:

8 (from 5,7) A

9 (from 3,6) $\neg A$

10 (from 8,9) $\perp$

2) A boy and a girl are talking. "I am a boy" said the child with black hair. "I am a girl" said the child with white hair. At least one of them is lying. Write down a knowledge base that describes this riddle. Show with resolution that both of them are lying.

We use the following propositions:

- W_t: White haired child is telling the truth.
- W_b: White haired child is a boy.
- B_t: Black haired child is telling the truth.
- B_b: Black haired child is a boy.

We have the following clauses;

1 $B_b \vee W_b$ ("A boy and a girl is talking" means that at least one of them has to be a boy.)

2 $\neg B_b \vee \neg W_b$ (With the same logic, at least one of them has to be a girl.)

3 $\neg B_t \vee B_b$ (If the black haired child is telling the truth, it has to be a boy. That is, $B_t \Rightarrow B_b$.)

4 $B_t \vee \neg B_b$ (If the black haired child is lying, it has to be a girl. That is, $\neg B_t \Rightarrow \neg B_b$.)

5 $\neg W_t \vee \neg W_b$ (If the white haired child is telling the truth, it has to be a girl. That is, $W_t \Rightarrow \neg W_b$.)

6 $W_t \vee W_b$ (If the white haired child lying, it has to be a boy. That is, $\neg W_t \Rightarrow W_b$.)

7 $\neg B_t \vee \neg W_t$ (At least one of them is lying.)

We want to show that both of them are lying. That is, $\neg B_t \wedge \neg W_t$. Negating this, we get the following clause:

8 $B_t \vee W_t$ (Assume that at least one of them is telling the truth.)

We use resolution to derive the empty clause as follows:

9 (from 3,8) $B_b \vee W_t$

10 (from 5,9) $B_b \vee \neg W_b$

11 (from 1,10) B_b

12 (from 2,10) $\neg W_b$

13 (from 4,11) B_t

14 (from 6,12) W_t

15 (from 7,13) $\neg W_t$

16 (from 14,15) $\perp$

Backward Chaining

3) The rule base for a production system is given below:

- If Horse(X) and Offspring (Y,X) then Horse(Y).

- If Parent(X,Y) then Offspring(Y,X).
- If Offspring(X,Y) then Parent(Y,X).
- Horse(Bluebeard).
- Parent(Bluebeard, Charlie).

Use backward chaining to show that Horse(Charlie) is true.

- **?-Horse(Charlie).** ?- is used to denote a query that we want to satisfy.
- **?-Horse(X) and ?-Offspring(Charlie, X).** We use the first rule, since it is the only rule that matches Horse(Charlie). We might have needed to branch if there were more rules that matched Horse(Charlie).
- **?-Horse(Bluebeard) and ?-Offspring(Charlie, Bluebeard).** Both the first rule and Horse(Bluebeard) matches Horse(X). We take a guess that X = Bluebeard and try to prove it. If it does not work, we need to backtrack to this point and try the former option.
- **?-Horse(Bluebeard) and ?-Parent(Bluebeard, Charlie)**. Only the second rule matches Offspring(Charlie, Bluebeard).
- **Horse(Charlie) = true.** Since we have reached facts that are in the working memory.

Semantic Networks

4) Exactly how can a computer determine that the sentence "I keep my money in the bank" refers to a financial institution rather than the land alongside a river. In this context, explain also what spreading activation is.

If the semantic network has nodes for both meanings of the word 'bank,' they get both activated with an initial weight, along with any other nodes that correspond to concepts from the given sentence. Any active node then activates its neighbors with a lower weight, essentially propagating its activation throughout the network. The activation of a node is the higher, the more highly activated nodes are in close distance to it in the semantic network. The node that corresponds to the 'financial institution' meaning of 'bank' will thus be more highly activated than the node that corresponds to the 'land alongside a river' meaning since it is closer to the node corresponding to 'money.'

5) What are advantages and disadvantages of using semantic networks for knowledge representation over using first-order logic?

Advantages:

- Semantic networks are easier to read and understand by humans.
- They are easier to implement and can be more efficient (since they can use special purpose procedures).

- They can be more expressive than first-order logic in some regards (for instance, inheritance with exceptions).

Disadvantages:

- They are less expressive than first-order logic in some regards (for instance, negation and disjunction are problems).
- Their semantics is often not well defined.
- They have problems with multiple inheritance of incompatible properties.