RESOLUTION AND FORWARD CHAINING

CSE 511A: Introduction to Artificial Intelligence

INFERENCE ALGORITHMS

Generally, four ways to check for entailment:

- Brute-force model checking
- Resolution
- Forward chaining
- Backward chaining

NORMAL FORMS

- Disjunctive normal form (DNF):
  - Disjunction of conjuncts: e.g., $(\neg P \wedge Q) \vee (\neg R \wedge \neg S \wedge T)$
- Conjunctive normal form (CNF):
  - Conjunction of disjuncts: e.g., $(\neg P \vee Q) \wedge (\neg R \vee \neg S \vee T)$
- Horn form:
  - Conjunction of *Horn clauses* (clauses with 0 or 1 positive literal): e.g., $(\neg P \vee Q) \wedge (\neg R \vee \neg S \vee T)$
  - Often written as set of implications: e.g., $(P \Rightarrow Q) \wedge ((R \wedge S) \Rightarrow T))$

MODUS PONENS

$(P \vee Q) \wedge (\neg Q \vee R)$ entails $(P \vee R)$

If Q is true, then R must be true.

If Q is false, then P must be true.

Thus, $(P \vee R)$ must be true.

RESOLUTION

- High-level idea of inference by resolution:
  - Proof by contradiction
  - Instead of showing that a KB entails a query, we show that if
    (1) we include the *negation* of the query in the KB, and
    (2) prove that the KB is *unsatisfiable*, then
    (3) the query must be true

ENTAILMENT

H	T	IW	UL	H⇒IW	T⇒UL	H⇔¬T	IW⇔UL
T	T	T	T	T	T	F	T
T	T	T	F	T	F	F	F
T	T	F	T	F	T	F	F
T	T	F	F	F	F	F	T
T	F	T	T	T	T	T	T
T	F	T	F	T	F	T	F
T	F	F	T	F	T	T	F
T	F	F	F	F	T	T	T
F	T	T	T	T	T	T	T
F	T	T	F	T	F	T	F
F	T	F	T	T	T	T	F
F	T	F	F	T	F	T	T
F	F	T	T	T	T	F	T
F	F	T	F	T	T	F	F
F	F	F	T	T	T	F	F
F	F	F	F	T	T	F	T

IW is true for every model where the KB is true

RESOLUTION

KB:

H⇒IW T⇒UL H⇔¬T IW⇔UL

¬HvIW ¬TvUL TvH ¬Hv¬T ¬IWvUL ¬ULvIW

negation of query:

¬IW

RESOLUTION

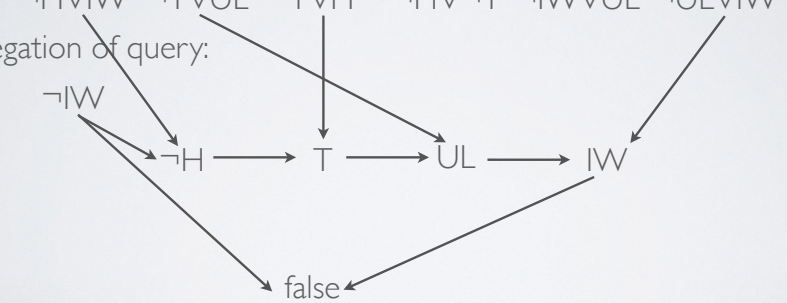
KB:

H⇒IW T⇒UL H⇔¬T IW⇔UL

¬HvIW ¬TvUL TvH ¬Hv¬T ¬IWvUL ¬ULvIW

negation of query:

¬IW



INFERENCE ALGORITHMS

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FORWARD CHAINING

- Instead of resolution, you can also use modus ponens to infer if a query is true
- Approach is called forward chaining.
- High-level idea:
  - Use modus ponens to add more and more clauses into the KB
  - If one of the clauses added is the query, then the query is entailed

FORWARD CHAINING

KB:

H⇒IW T⇒UL H⇔¬T IW⇔UL

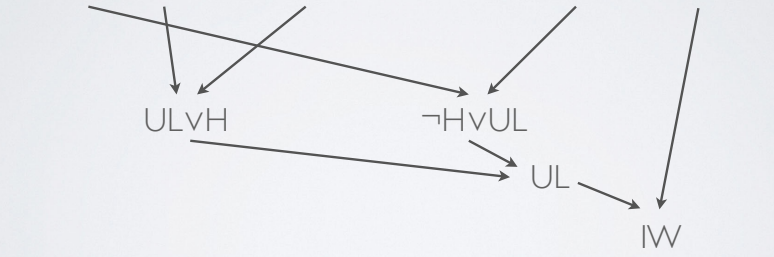
¬HvIW ¬TvUL TvH ¬Hv¬T ¬IWvUL ¬ULvIW

FORWARD CHAINING

KB:

H⇒IW T⇒UL H⇔¬T IW⇔UL

¬HvIW ¬TvUL TvH ¬Hv¬T ¬IWvUL ¬ULvIW



EXERCISE

- If the unicorn is mythical, then it is immortal, but if it is not mythical, then it is a mortal mammal. If the unicorn is either immortal or a mammal, then it is horned. The unicorn is magical if it is horned.

- Prove that the unicorn is magical using resolution and forward chaining