

# BACKWARD CHAINING

CSE 511A: Introduction to Artificial Intelligence

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# INFERENCE ALGORITHMS

Generally, four ways to check for entailment:

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

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# BACKWARD CHAINING

- High-level idea of inference by backward chaining:
  - Just like resolution, prove that the KB + negation of query is unsatisfiable
  - Instead of checking for unsatisfiability using modes ponens like in resolution, check for unsatisfiability using algorithms like DPLL
  - Find if there are any assignment of truth values that satisfies all clauses in the KB + negation of query
    - If there is one possible assignment, then query is not entailed
    - If there are no possible assignments, then query is entailed

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# BACKWARD CHAINING

DPLL (*clauses*, *symbols*, *model*)

- (1) return true if every clause in *clauses* are true with *model*
- (2) return false if some clause in *clauses* are false with *model*
- (3) find *pure symbols* (*P*, *value*)
- (4) if there are pure symbols, then  
return DPLL(*clauses*, *symbols* - *P*, *model*  $\cup$  {*P* = *value*})
- (5) find *unit clauses* (*P*, *value*)
- (6) if there are unit clauses, then  
return DPLL(*clauses*, *symbols* - *P*, *model*  $\cup$  {*P* = *value*})
- (7) pick *any symbol* *P*
- (8) return DPLL(*clauses*, *symbols* - *P*, *model*  $\cup$  {*P* = true}) or  
DPLL(*clauses*, *symbols* - *P*, *model*  $\cup$  {*P* = false})

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# BACKWARD CHAINING

Pure symbols:

- A symbol that appears with the same “sign” in all clauses that are not yet known to be true
- e.g., in  $(A)$ ,  $(A \vee \neg B)$ ,  $(\neg B \vee \neg C)$ ,  $(C \vee A)$ ,  $A$  and  $B$  are pure symbols.  
If  $A$  is assigned true, then both  $B$  and  $C$  are pure symbols since the 1st, 2nd and 4th clauses are now known to be true.

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# BACKWARD CHAINING

Unit clause:

- Clauses with only one remaining literal whose truth value hasn't been assigned
- e.g., in  $(A)$ ,  $(A \vee \neg B)$ ,  $(\neg B \vee \neg C)$ ,  $(C \vee A)$ ,  $(A)$  is a unit clause.  
If  $B$  is assigned true, then  $(\neg B \vee \neg C)$  simplifies to  $(\neg C)$ , which is then also a unit clause.

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## BACKWARD CHAINING EXAMPLE

$\text{UFOs\_Kidnap\_Me} \wedge \text{The\_FBI\_Taps\_My\_Phone} \Rightarrow \text{I\_Freak}$   
 $\text{I\_Freak} \wedge \text{Wear\_Tinfoil\_Hat} \Rightarrow \text{Elvis\_is\_Alive}$   
 $\text{I\_Find\_Tinfoil} \wedge \text{Transmitters\_Implanted\_in\_Brain} \Rightarrow \text{Wear\_Tinfoil\_Hat}$   
 $\text{The\_FBI\_is\_Bored} \Rightarrow \text{The\_FBI\_Taps\_My\_Phone}$   
 $\text{I\_Watch\_Too\_Much\_X\_Files}$   
 $\text{I\_Find\_Tinfoil}$   
 $\text{Transmitters\_Implanted\_in\_Brain}$   
 $\text{UFOs\_Kidnap\_Me}$   
 $\text{Taking\_My\_Haldol}$   
 $\text{The\_FBI\_is\_Bored}$

Prove that  $\text{Elvis\_is\_Alive}$

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## BACKWARD CHAINING EXAMPLE

$\neg \text{UFOs\_Kidnap\_Me} \vee \neg \text{The\_FBI\_Taps\_My\_Phone} \vee \text{I\_Freak}$   
 $\neg \text{I\_Freak} \vee \neg \text{Wear\_Tinfoil\_Hat} \vee \text{Elvis\_is\_Alive}$   
 $\neg \text{I\_Find\_Tinfoil} \vee \neg \text{Transmitters\_Implanted\_in\_Brain} \vee \text{Wear\_Tinfoil\_Hat}$   
 $\neg \text{The\_FBI\_is\_Bored} \vee \text{The\_FBI\_Taps\_My\_Phone}$   
 $\text{I\_Watch\_Too\_Much\_X\_Files}$   
 $\text{I\_Find\_Tinfoil}$   
 $\text{Transmitters\_Implanted\_in\_Brain}$   
 $\text{UFOs\_Kidnap\_Me}$   
 $\text{Taking\_My\_Haldol}$   
 $\text{The\_FBI\_is\_Bored}$   
 $\neg \text{Elvis\_is\_Alive}$

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# BACKWARD CHAINING EXAMPLE

Found pure symbol: I\_Watch\_Too\_Much\_X\_Files: T

Found pure symbol: Taking\_My\_Haldol: T

Found unit clause: Elvis\_is\_Alive: F

Found unit clause: The\_FBI\_is\_Bored: T

Found unit clause: UFOs\_Kidnap\_Me: T

Found unit clause: Transmitters\_Implanted\_in\_Brain: T

Found unit clause: I\_Find\_Tinfoil: T

Found unit clause: The\_FBI\_Taps\_My\_Phone: T

Found unit clause: Wear\_Tinfoil\_Hat: T

Found unit clause: I\_Freak: F