جامعة المستقبل
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كلية العلـــوم
قـســــــــم علوم الذكاء الاصطناعي

المحاضرة الخامسة

المادة : *Knowledge representation*
المرحلة : الأولى
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d_1) Backward Resolution

The proving for ***happy(john)*** using **Backward Resolution** is shown as follows:

1. ¬pass(X,ai_exam)∨¬win(X,lottery)∨happy(X)
2. pass(Y,E)∨¬study(Y)
3. pass(M,G)∨¬lucky(M)
4. ¬study(john)
5. lucky(john).
6.¬lucky(Z)∨win(Z,lottery).
7.¬happy(john).

7: ¬happy(john) **1**:¬pass(X,ai_exam)∨¬win(X,lottery)∨ happy(X) {X=john}

8: ¬pass(john, ai_exam)∨¬win(john,lottery) **6**: ¬lucky(Z)∨win(Z,lottery){Z=john}

9: ¬pass(john, ai_exam)∨¬lucky(john) **5**: lucky(john)

10: ¬pass(john, ai_exam) **3**: pass(M,G)∨¬lucky(M) {M=john, G=ai_exam}

11: ¬lucky(john) **5**: lucky(john)

12: □ {the empty clause}

∴ John is happy

d_2) Forward Resolution

The proving for ***happy(john)*** using **Forward Resolution** is shown as follows:

1. ┐pass(X,ai_exam)∨┐win(X,lottery)∨happy(X)
2. pass(Y,E)∨┐study(Y)
3. pass(M,G)∨┐lucky(M)
4. ┐study(john)
5. lucky(john).
6.┐lucky(Z)∨win(Z,lottery).
7.┐happy(john).

1:┐pass(X,ai_exam)∨┐win(X,lottery)∨happy(X) **6**: ┐lucky(Z)∨win(Z, lottery){Z=X}

8: ┐ pass(X,ai_exam)∨happy(X) ∨ ┐lucky(X) **5**: lucky(john) {X=john}

9:┐ pass(john, ai_exam)∨happy(john) **3**: pass(M,G)∨┐lucky(M) {M=john, G=ai_exam}

10: happy(john) ∨ ┐lucky(john) **5**: lucky(john)

11 : happy(john) 7: ┐happy(john)

12: □ {the empty clause}

∴ John is happy

Example2: Given the following Predicate logic statements, prove $\exists W \neg s(W)$ using Backward resolution:

(1) $\forall X [(\forall Y\, s(Y) \wedge v(X, Y)) \Rightarrow ((\exists Z \neg t(X, Z)) \wedge v(X, X))]$

(2) $\forall X \forall Y\, s(Y) \Rightarrow t(X,Y) \wedge v(X,Y)$

B. Convert the predicate logic statements to clause form:

Solution:

(1) **$\forall X [(\forall Y\, s(Y) \wedge v(X, Y)) \Rightarrow ((\exists Z \neg t(X, Z)) \wedge v(X, X))]$**

1-1) **Remove $\Rightarrow$:** $\forall X [\neg(\forall Y\, s(Y) \wedge v(X,Y)) \vee ((\exists Z \neg t(X,Z)) \wedge v(X,X))]$

1-2) **Reduce $\neg$:** $\forall X [(\exists Y \neg s(Y) \vee \neg v(X,Y)) \vee ((\exists Z \neg t(X,Z)) \wedge v(X,X))]$

1-3) **Standardize Variables:** Nothing to do here.

1-4) **Move quantifiers:** $\forall X \exists Y \exists Z [(\neg s(Y) \vee \neg v(X,Y)) \vee (\neg t(X,Z) \wedge v(X,X))]$

1-5) **Remove $\exists$:** $\forall X [(\neg s(f1(X)) \vee \neg v(X,f1(X))) \vee (\neg t(X,f2(X)) \wedge v(X,X))]$

1-6) **Remove ∀:** $(\neg s(f1(X)) \lor \neg v(X,f1(X))) \lor (\neg t(X,f2(X)) \land v(X,X))$

1-7) **CNF:** $(\neg s(f1(X)) \lor \neg v(X,f1(X)) \lor \neg t(X,f2(X))) \land (\neg s(f1(X)) \lor \neg v(X,f1(X)) \lor v(X,X))$

1-8) **Split ∧:** $\neg s(f1(X)) \lor \neg v(X,f1(X)) \lor \neg t(X,f2(X))$

$\neg s(f1(X)) \lor \neg v(X,f1(X)) \lor v(X,X)$

1-9) **Standardize Variables:**

$\neg s(f1(X)) \lor \neg v(X,f1(X)) \lor \neg t(X,f2(X))$

$\neg s(f3(X3)) \lor \neg v(X3,f3(X3)) \lor v(X3,X3)$

(2) $\forall N \forall M\ s(M) \Rightarrow t(N, M) \wedge v(N, M)$

2-1) **Remove ⇒:** $\forall N \forall M\ \neg s(M) \vee (t(N, M) \wedge v(N, M))$

2-2) 2-3)2-4)2-5) Nothing to do here

2-6) **Remove ∀:** $\neg s(M) \vee (t(N, M) \wedge v(N, M))$

2-7) **CNF:** $(\neg s(M) \vee t(N, M)) \wedge (\neg s(M) \vee v(N, M))$

2-8) **Split ∧:** $\neg s(M) \vee t(N, M)$

$\neg s(M) \vee v(N, M)$

2-9) **Standardize Variables:**

$\neg s(M) \vee t(N, M)$

$\neg s(M1) \vee v(N1, M1)$

After applying the **clause form** method, the **two** sentences become **four** clauses as follows:

- **¬s(f1(X))** ∨ **¬v(X,f1(X))** ∨ **¬ t(X,f2(X))**
- **¬s(f3(X3))** ∨ **¬v(X3,f3(X3))** ∨ **v(X3,X3)**
- **¬s(M)** ∨ **t(N, M)**
- **¬s(M1)** ∨ **v(N1, M1)**

***C.* Add the negation of what is to be proved** **∃W ¬ s(W)**

Thus, **∃W ¬ s(W)** become **s(W)** because **¬(∃W ¬ s(W)) = ∀W s(W) = s(W).** Now we have a new clause (5**. s(W).**)

added to the other four clauses and shown below:

- **¬s(f1(X))** ∨ **¬v(X,f1(X))** ∨ **¬ t(X,f2(X))**
- **¬s(f3(X3))** ∨ **¬v(X3,f3(X3))** ∨ **v(X3,X3)**
- **¬s(M)** ∨ **t(N, M)**
- **¬s(M1)** ∨ **v(N1, M1)**
- **s(W)**

D. Backward Resolution

1. ¬s(f1(X)) ∨ ¬v(X,f1(X)) ∨ ¬ t(X,f2(X))
2. ¬s(f3(X3)) ∨ ¬v(X3,f3(X3)) ∨ v(X3,X3)
3. ¬s(M) ∨ t(N, M)
4. ¬s(M1) ∨ v(N1, M1)
5. s(W)

5: s(W) 2: ¬s(f3(X3)) ∨ ¬v(X3,f3(X3)) ∨ v(X3,X3) {f3(X3)=W}

6: ¬v(X3,W) ∨ v(X3,X3) 4: ¬s(M1) ∨ v(N1, M1) { N1=X3, M1=W}

7: v(X3,X3) ∨ ¬s(W) 1: ¬s(f1(X)) ∨ ¬v(X,f1(X)) ∨ ¬ t(X,f2(X)) {X=X3, f1(X)=X3}

8: ¬s(W) ∨ ¬s(X3) ∨ ¬ t(X3,f2(X)) 3: ¬s(M) ∨ t(N, M) { N=X3,M=f2(X)}

9: ¬s(W) ∨ ¬s(X3) ∨ ¬s(f2(X)) 5. s(W) {f2(X)=W}

10: ¬s(W) ∨ ¬s(X3) 5. s(W) {X3=W}

11: ¬s(W) 5. s(W)

12: ( ) { Empty clause}