Introduction to AI
-Tutorial Logic for KRR -

Francesca Toni

Colonel West again

Criminal(x) ← American(x), Weapon(y), Sells(x, y, z), Hostile(z)

Owns(Nono,M1)

Missile(M1)

Sells(West, x,Nono) ← Owns(Nono,x), Missile(x)

American(West)

Weapon(x) ← Missile(x)

Hostile(x) ← Enemy(x,America)

Enemy(Nono,America)

1) Compute using SLD resolution all possible answers for the query (∃**x)** Criminal(**x**)
2) Give the minimal Herbrand model of this set of definite clauses
3) Let S be the set of all these clauses. Determine $T_S\uparrow^1$, $T_S\uparrow^2$ and $T_S\uparrow^3$ and the least fixed point of T_S

1) Another query/goal for Colonel West

← Criminal(**x**)

|

← American(x), Weapon(y), Sells(West, y, z),Hostile(z)

{x/West} |

← Weapon(y), Sells(West, y, z),Hostile(z)

|

← Missile(y), Sells(West, y, z),Hostile(z)

|

← Sells(West,M1, z),Hostile(z)

|

← Owns(Nono,M1),Missile(M1),Hostile(Nono)

|

← Hostile(Nono)

|

← Enemy(Nono,America)

|

□

Answer: substitution {x/West}

2) Minimal Herbrand model

{Enemy(Nono,America), American(West), Missile(M1), Owns(Nono,M1), Hostile(Nono), Weapon(M1), Sells(West, M1,Nono), Criminal(West)}

3) $T_S\uparrow^1$ ={Enemy(Nono,America), American(West), Missile(M1), Owns(Nono,M1)}

$T_S\uparrow^2 = T_S\uparrow^1 \cup$ {Hostile(Nono), Weapon(M1), Sells(West, M1,Nono)}

$T_S\uparrow^3 = T_S\uparrow^2 \cup$ {Criminal(West)}

Least fixed point of T_S = {Enemy(Nono,America), American(West), Missile(M1), Owns(Nono,M1), Hostile(Nono), Weapon(M1), Sells(West, M1,Nono), Criminal(West)}= $T_S\uparrow^3$

Search for solutions by SLD resolution

Admires(Ann, Bob) Admires(Ann, Carla) Admires(x,y) ← Lecturer(x), Lecturer(y)

Lecturer(Ann) Lecturer(Dave) Lecturer(Eric)

Rich(Carla) Rich(Eric) Rich(Ann) ← Rich(Carla)

Which rich person does Ann admire?

Formulate this query and compute all possible answers obtainable by SLD resolution, using depth-first search with backtracking. Show all failed attempts explicitly.

Search for solutions

Admires(Ann, Bob) Admires(Ann, Carla) Admires(x,y) ← Lecturer(x), Lecturer(y)

Lecturer(Ann) Lecturer(Dave) Lecturer(Eric)

Rich(Carla) Rich(Eric) Rich(Ann) ← Rich(Carla)

Which rich person does Ann admire?

← Admires(Ann,z),Rich(z)

{z/Bob} |

← Rich(Bob)

failure *but this is not the only possible derivation – backtrack*

retry ← Admires(Ann,z),Rich(z)

{z/Carla} |

← Rich(Carla)

|

□ {z/Carla} *any other answers? - backtrack*

Search for solutions

Admires(Ann, Bob) Admires(Ann, Carla) Admires(x,y) ← Lecturer(x), Lecturer(y)

Lecturer(Ann) Lecturer(Dave) Lecturer(Eric)

Rich(Carla) Rich(Eric) Rich(Ann) ← Rich(Carla)

Which rich person does Ann admire?

retry ← Admires(Ann,z),Rich(z)

|

← Lecturer(Ann),Lecurer(z), Rich(z)

|

← Lecurer(z), Rich(z)

{z/Ann} |

← Rich(Ann)

|

← Rich((Carla))

|

□ {z/Ann} *any other answers? - backtrack*

retry ← Lecurer(z), Rich(z)

{z/Dave} |

← Rich(Ann)

fails

retry ← Lecurer(z), Rich(z)

{z/Eric} |

← Rich(Eric)

|

□ {z/Eric}

Computed answers: {z/Carla} , {z/Ann} , {z/Eric}

More on search for solutions by SLD resolution

Consider the set of definite clauses (written using logic programming notation: variables start with capital letters)

S ={ p(X) ← q(X,Y), r(Y), q(2,3) ←, q(2,4) ←, r(4) ← , r(3) ← r(3) }

and query p(X). Apply 1 step of SLD resolution to obtain q(X,Y), r(Y):

1) Does it matter in which order q(X,Y) and r(Y) are selected for determining an answer?

2) Does it matter in which order clauses are chosen for determining an answer?

More on search for solutions by SLD resolution – sample answers/solutions

1) No. Indeed, independently of whether q(X,Y) or r(Y) is selected first, the same answer {X/2} can be computed.
2) Yes. Indeed, if q(X,Y) is selected first and the clause q(2,3) ← is chosen, then no answer is computed (without loop checking); analogously if r(Y) is selected first and the clause r(3) ← r(3) is chosen. So the choice of clause may affect termination