

Introduction to AI -Tutorial Logic for KRR -

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Colonel West again

$\text{Criminal}(x) \leftarrow \text{American}(x), \text{Weapon}(y), \text{Sells}(x, y, z), \text{Hostile}(z)$

$\text{Owns}(\text{Nono}, \text{M1})$

$\text{Missile}(\text{M1})$

$\text{Sells}(\text{West}, x, \text{Nono}) \leftarrow \text{Owns}(\text{Nono}, x)$

$\text{American}(\text{West})$

$\text{Weapon}(x) \leftarrow \text{Missile}(x)$

$\text{Hostile}(x) \leftarrow \text{Enemy}(x, \text{America})$

$\text{Enemy}(\text{Nono}, \text{America})$

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- 1) Compute using SLD resolution all possible answers for the query $(\exists x) \text{Criminal}(x)$
- 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)
|
□
```

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

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

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

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

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)

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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) $\text{Admires}(x,y) \leftarrow \text{Lecturer}(x), \text{Lecturer}(y)$
Lecturer(Ann) Lecturer(Dave) Lecturer(Eric)
Rich(Carla) Rich(Eric) $\text{Rich}(Ann) \leftarrow \text{Rich}(Carla)$

Which rich person does Ann admire?

$\leftarrow \text{Admires}(Ann,z), \text{Rich}(z)$

{z/Bob} |

$\leftarrow \text{Rich}(Bob)$

failure

but this is not the only possible derivation - backtrack

retry $\leftarrow \text{Admires}(Ann,z), \text{Rich}(z)$

{z/Carla} |

$\leftarrow \text{Rich}(Carla)$

|

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

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Search for solutions

Admires(Ann, Bob) Admires(Ann, Carla) Admires(x,y) \leftarrow Lecturer(x), Lecturer(y)
Lecturer(Ann) Lecturer(Dave) Lecturer(Eric)
Rich(Carla) Rich(Eric) Rich(Ann) \leftarrow Rich(Carla)

Which rich person does Ann admire?

retry \leftarrow Admires(Ann,z),Rich(z)

|
 \leftarrow Lecturer(Ann),Lecurer(z), Rich(z)

|
 \leftarrow Lecurer(z), Rich(z)

{z/Ann} |
 \leftarrow Rich(Ann)

|
 \leftarrow Rich((Carla))

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

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

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retry \leftarrow Lecurer(z), Rich(z)

{z/Dave} |
 \leftarrow Rich(Ann)

fails

retry \leftarrow Lecurer(z), Rich(z)

{z/Eric} |
 \leftarrow Rich(Eric)

|
☐ {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)

$S = \{ p(X) \leftarrow q(X,Y), r(Y), q(2,3) \leftarrow, q(2,4) \leftarrow, r(4) \leftarrow, r(3) \leftarrow r(3) \}$

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 $q(2,3) \leftarrow$ is chosen, then no answer is computed (without loop checking); analogously if $r(Y)$ is selected first and the clause $r(3) \leftarrow r(3)$ is chosen. So the choice of clause may affect termination