Programming with Fuzzy Logic Rules by using the FLOPER Tool

Pedro J. Morcillo and Ginés Moreno

{pmorcillo,gmoreno}@dsi.uclm.es

http://www.dsi.uclm.es/investigacion/dect/FLOPERpage.htm

Department of Computing Systems

University of Castilla – La Mancha, SPAIN

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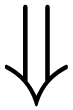
Multi-Adjoint Logic Programs

FUZZY LOGIC PROGRAMMING



FUZZY LOGIC

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LOGIC PROGRAMMING

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Multi-Adjoint Logic Programs

$p(X)$	<prod	$q(X,Y)$ &godel $r(Y)$	with 0.8
$q(a,Y)$	<prod	$s(Y)$	with 0.7
$q(b,Y)$	<luka	$r(Y)$	with 0.8
$r(\_)$			with 0.6
$s(b)$			with 0.9

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$$p(X,TV0) \quad :- \quad q(X,Y,TV1), r(Y,TV2), and\_godel(TV1,TV2,TV3), and\_prod(0.8,TV3,TV0).$$

$$q(a,Y,TV0) \quad :- \quad s(Y,TV1), and\_prod(0.7,TV1,TV0).$$

$$q(b,Y,TV0) \quad :- \quad r(Y,TV1), and\_luka(0.8,TV1,TV0).$$

$$r(\_,0.6). \qquad s(b,0.9).$$

Programming with Fuzzy Logic Rules by using the FLOPER Tool

The Prototype Tool

- The system has been implemented with approximately 300 Sicstus Prolog clauses and it uses DCG's for defining parsing predicates

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Programming with Fuzzy Logic Rules by using the FLOPER Tool

The Prototype Tool

- The system has been implemented with approximately 300 Sicstus Prolog clauses and it uses DCG's for defining parsing predicates
- The `prelude.pl` defines default aggregators
- Options for...
  - Loading a prolog file with extension ".pl"
  - Parsing a ".fpl" fuzzy program. The generated Prolog code is also asserted in the system
  - Saving the generated Prolog code into a ".pl" file
  - Listing both the fuzzy and Prolog code
  - Clean, Stop and Quit

Programming with Fuzzy Logic Rules by using the FLOPER Tool

The Prototype Tool

- Introducing a goal: `p(X) &godel r(a)`

Programming with Fuzzy Logic Rules by using the FLOPER Tool

The Prototype Tool

- Introducing a goal: $\texttt{p(X) \&godel r(a)}$
- Run: $[\texttt{Truth} = 0.3199, \texttt{X} = \texttt{b}]$ $[\texttt{Truth} = 0.48, \texttt{X} = \texttt{a}]$
  $\texttt{p(X, \_TV0), r(a, \_TV1), and\_godel(\_TV0, \_TV1, Truth)}$

Programming with Fuzzy Logic Rules by using the FLOPER Tool

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  ..... by using a PROLOG-based, low level representation of the fuzzy code.....

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  `p(X, _TV0), r(a, _TV1), and_godel(_TV0, _TV1, Truth)`

  ..... by using a PROLOG-based, low level representation of the fuzzy code.....
- New DEBUGGING options.....
  - Depth. Fix the maximum evaluation level
  - Tree. Generate the associated evaluation tree (more precise information on computations)
  - Transformations. Open menu for F/U, PE,...

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Debugging capabilities of FLOPER

```
p(X) <prod q(X,Y) &godel r(Y) with 0.8
```

⇓

```
p(X,TV0) :- q(X,Y,TV1),r(Y,TV2),
  and_g(TV1,TV2,TV3),and_p(0.8,TV3,TV0).
```

⇓

```
rule(number(1),
     head(atom(pred(p,1),[var('X')])),
     impl(prod),body(and(godel, 2,
     [atom(pred(q,2),[var('X'),var('Y')]),
      atom(pred(r,1),[var('Y')])])),
     td(0.8)).
```

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Debugging capabilities of FLOPER

- Trace 1: solutions in presence of infinite branches

R1: p(X) <prod q(X) with 0.9. R2: p(X) <godel r(X) with 0.8.
R3: q(X) <luka q(X) with 0.7. R4: r(a) with 0.6.

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Debugging capabilities of FLOPER

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- TREE: Execution tree with depth 4 for goal `p(a)`

Programming with Fuzzy Logic Rules by using the FLOPER Tool

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- TREE: Execution tree with depth 4 for goal `p(a)`

```
R0 < p(a), {} >
   R1 < &prod(0.9,q(a)), {X1/a} >
       R3 < &prod(0.9,&luka(0.7,q(a))), {X1/a,X7/a} >
           R3 < &prod(0.9,&luka(0.7,&luka(0.7,q(a)))), {X1/a,X7/a,..>
               R3 < &prod(0.9,&luka(0.7,&luka(0.7,&luka(0.7,q(a))))),
                                  ..............
   R2 < &godel(0.8,r(a)), {X2/a} >
       R4 < &godel(0.8,0.6), {X2/a} >
```

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Debugging capabilities of FLOPER

- Trace 2: solutions even with unsuccessful atoms

  $\texttt{p(a)}$ <prod @aver$(1, \texttt{p(b)})$ with 0.9

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Debugging capabilities of FLOPER

- Trace 2: solutions even with unsuccessful atoms

  $\texttt{p(a)}$ <prod @aver$(1, \texttt{p(b)})$ with 0.9

  ... remember that the associated Prolog clause is:

  $$\texttt{p(a, TV0)} :- \mathbf{p(b, \_TV1)}, \texttt{agr\_aver}(1, \texttt{\_TV1}, \texttt{\_TV2}), \texttt{and\_prod}(0.9, \texttt{\_TV2}, \texttt{TV0}).$$

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Debugging capabilities of FLOPER

- Trace 2: solutions even with unsuccessful atoms

  `p(a)` <prod `@aver(1,p(b))` with 0.9

  ... remember that the associated Prolog clause is:

  ```
  p(a,TV0) :- p(b,_TV1),agr_aver(1,_TV1,_TV2),
                        and_prod(0.9,_TV2,TV0).
  ```

- TREE: Execution tree with depth 2 for goal `p(X)`

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Debugging capabilities of FLOPER

- Trace 2: solutions even with unsuccessful atoms

  $\texttt{p(a)}$ <prod @aver$(1, \texttt{p(b)})$ with 0.9

  ... remember that the associated Prolog clause is:

  $$\texttt{p(a, TV0)} :- \mathbf{p(b, \_TV1)}, \texttt{agr\_aver}(1, \texttt{\_TV1}, \texttt{\_TV2}), \texttt{and\_prod}(0.9, \texttt{\_TV2}, \texttt{TV0}).$$

- TREE: Execution tree with depth 2 for goal $\texttt{p(X)}$

```
R0 < p(X), {} >
        R1 < &prod(0.9,@aver(1,p(b))), {X/a} >
                R0 < &prod(0.9,@aver(1,0)), {X/a} >
```

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Conclusions and Further Research

- Fuzzy Logic Programming LANGUAGE:
  The Multi-Adjoint Logic Programming approach

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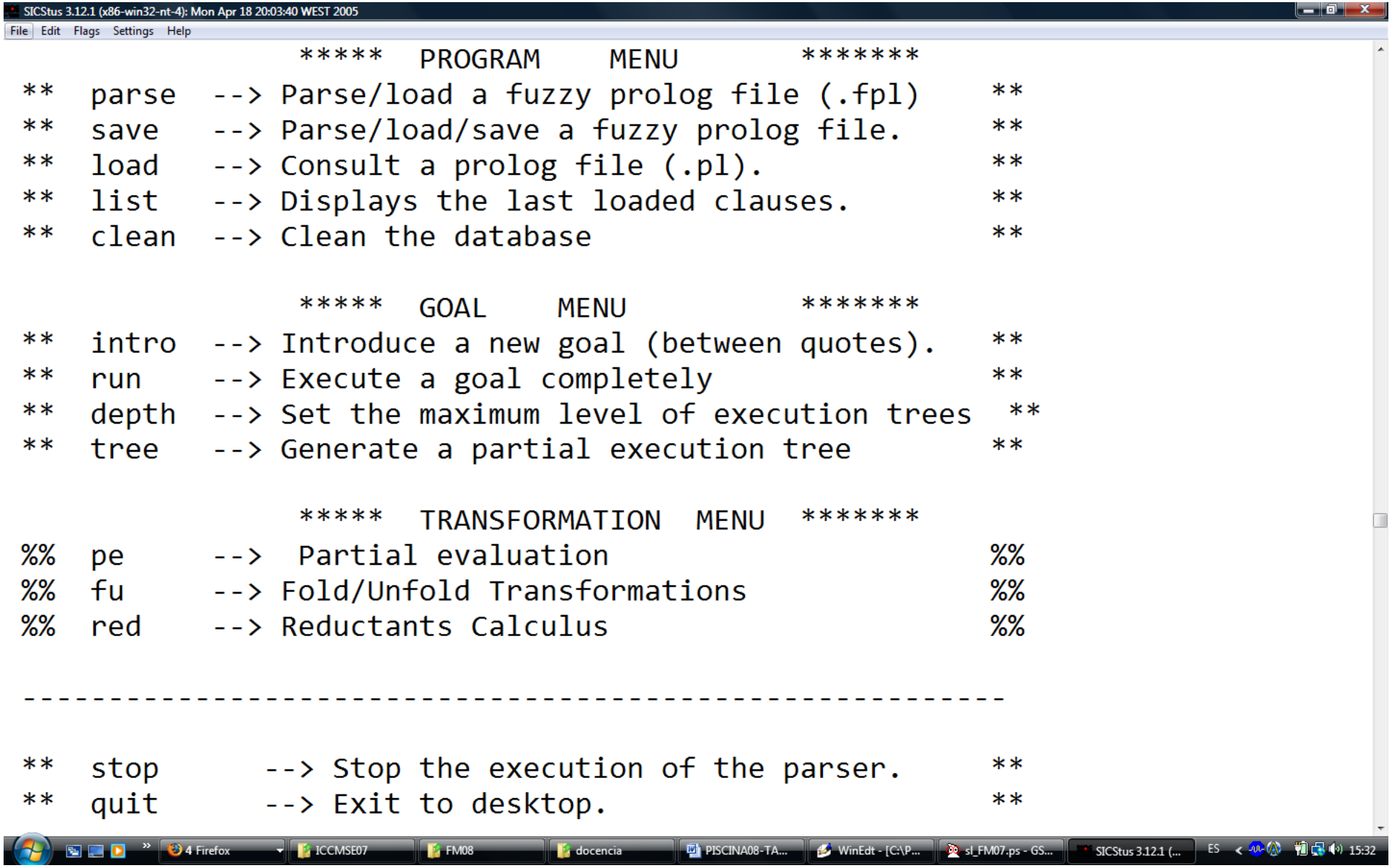
- Fuzzy Logic Programming LANGUAGE:
  The Multi-Adjoint Logic Programming approach
- FLOPER provides two implementation techniques
  - Compilation to Prolog code [RUN]: simplicity, transparency, complete evaluation of goals
  - Low level representation [DEBUG]: detailed data, unfolding trees, powerful manipulations

Programming with Fuzzy Logic Rules by using the FLOPER Tool

Conclusions and Further Research

- Fuzzy Logic Programming LANGUAGE:
  The Multi-Adjoint Logic Programming approach
- FLOPER provides two implementation techniques
  - Compilation to Prolog code [RUN]: simplicity, transparency, complete evaluation of goals
  - Low level representation [DEBUG]: detailed data, unfolding trees, powerful manipulations
- More efforts are needed for increasing expressivity (new lattices, more computation rules, graphical interface) and including transformation techniques (optimization, specialization, reductants.....)


SICStus 3.12.1 (x86-win32-nt-4): Mon Apr 18 20:03:40 WEST 2005
File Edit Flags Settings Help
***** PROGRAM MENU *******
** parse --> Parse/load a fuzzy prolog file (.fpl) **
** save --> Parse/load/save a fuzzy prolog file. **
** load --> Consult a prolog file (.pl). **
** list --> Displays the last loaded clauses. **
** clean --> Clean the database **
***** GOAL MENU *******
** intro --> Introduce a new goal (between quotes). **
** run --> Execute a goal completely **
** depth --> Set the maximum level of execution trees **
** tree --> Generate a partial execution tree **
***** TRANSFORMATION MENU *******
%% pe --> Partial evaluation %%
%% fu --> Fold/Unfold Transformations %%
%% red --> Reductants Calculus %%
** stop --> Stop the execution of the parser. **
** quit --> Exit to desktop. **
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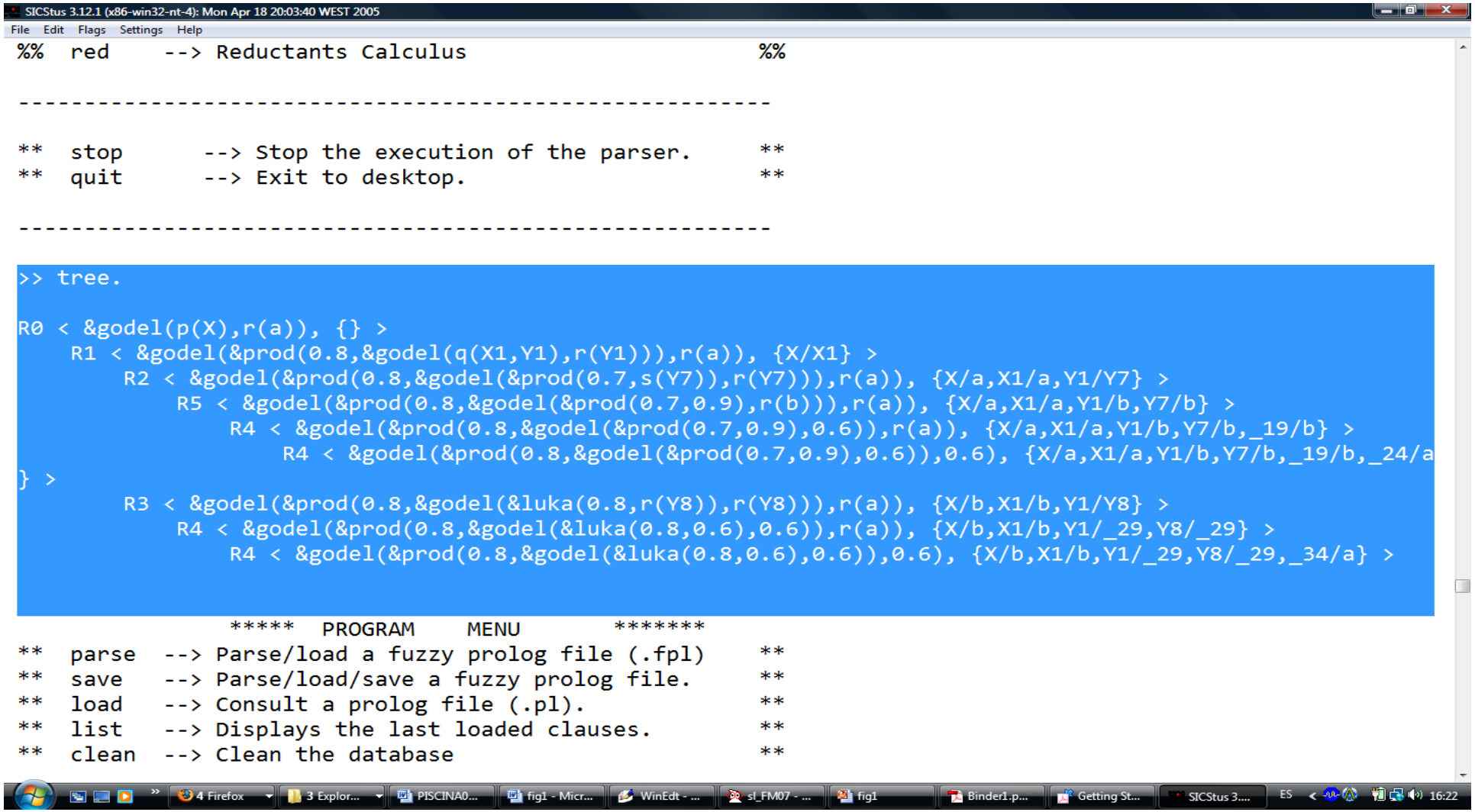
```
------------------------------------------------------------

>> list.

No loaded files.

ORIGINAL FUZZY-PROLOG CODE:
p(X) <prod q(X,Y) &godel r(Y) with 0.8.
q(a,Y) <prod s(Y) with 0.7.
q(b,Y) <luka r(Y) with 0.8.
r(_) with 0.6.
s(b) with 0.9.

GENERATED PROLOG CODE:
p(X,TV0):-q(X,Y,_TV2),r(Y,_TV3),and_godel(_TV2,_TV3,_TV5),and_prod(0.8,_TV5,T
V0).
q(a,Y,TV0):-s(Y,_TV1),and_prod(0.7,_TV1,TV0).
q(b,Y,TV0):-r(Y,_TV1),and_luka(0.8,_TV1,TV0).
r(_,0.6).
s(b,0.9).
```


SICStus 3.12.1 (x86-win32-nt-4): Mon Apr 18 20:03:40 WEST 2005
File Edit Flags Settings Help
%% red --> Reductants Calculus %%
** stop --> Stop the execution of the parser. **
** quit --> Exit to desktop. **
>> tree.
R0 < &godel(p(X),r(a)), {} >
R1 < &godel(&prod(0.8,&godel(q(X1,Y1),r(Y1))),r(a)), {X/X1} >
R2 < &godel(&prod(0.8,&godel(&prod(0.7,s(Y7)),r(Y7))),r(a)), {X/a,X1/a,Y1/Y7} >
R5 < &godel(&prod(0.8,&godel(&prod(0.7,0.9),r(b))),r(a)), {X/a,X1/a,Y1/b,Y7/b} >
R4 < &godel(&prod(0.8,&godel(&prod(0.7,0.9),0.6)),r(a)), {X/a,X1/a,Y1/b,Y7/b,_19/b} >
R4 < &godel(&prod(0.8,&godel(&prod(0.7,0.9),0.6)),0.6), {X/a,X1/a,Y1/b,Y7/b,_19/b,_24/a
} >
R3 < &godel(&prod(0.8,&godel(&luka(0.8,r(Y8)),r(Y8))),r(a)), {X/b,X1/b,Y1/Y8} >
R4 < &godel(&prod(0.8,&godel(&luka(0.8,0.6),0.6)),r(a)), {X/b,X1/b,Y1/_29,Y8/_29} >
R4 < &godel(&prod(0.8,&godel(&luka(0.8,0.6),0.6)),0.6), {X/b,X1/b,Y1/_29,Y8/_29,_34/a} >
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WinEdt - ...
sl_FM07 - ...
fig1
Binder1.p...
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