Features of the Expert-System-Shell SPIRIT

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Overview

Knowledge processing in SPIRIT

Reliability of answers

Graphs and hypergraphs

Recall by a stimulus

Conclusion and remarks

Knowledge processing in SPIRIT

Step 1: Definition of a knowledge domain

Specify variables V_l with respective values v_l; Literal $V_l = v_l$

e.g.: MARITAL=single, STUDENT=true.

Propositions formed by junctors $\wedge$ (and), $\vee$ (or), $\overline{\ }$ (not),

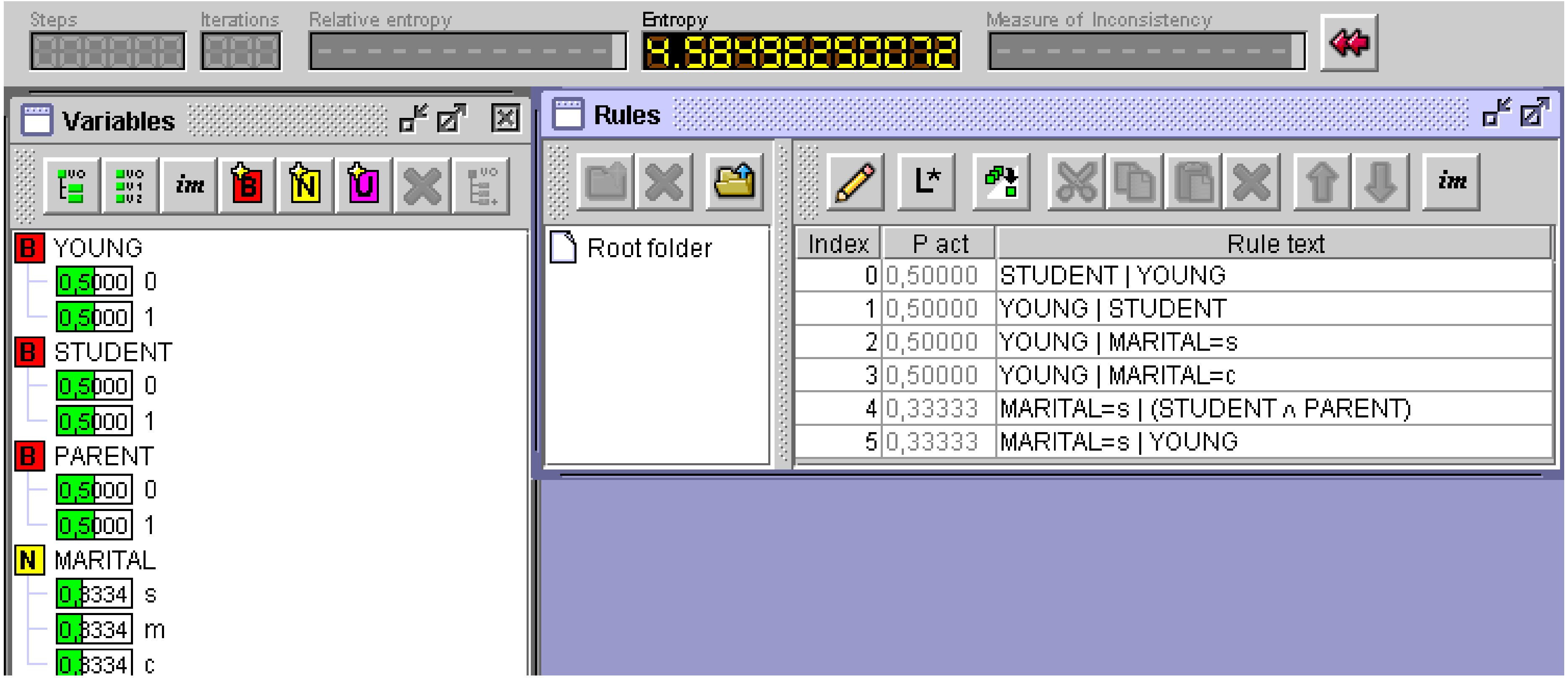
Denoted by $A,B,C \Rightarrow$ Propositional language L.

Extension to conditional language L|L by binary conditional operator $|$.

e.g.: MARITAL=single | (STUDENT=true $\wedge$ PARENT=true).

$B|A\ [x]$, A, $B \in$ L, $x \in [0;1]$.

Excursus



Steps
Iterations
Relative entropy
Entropy
Measure of Inconsistency
Variables
YOUNG
0,5000 0
0,5000 1
STUDENT
0,5000 0
0,5000 1
PARENT
0,5000 0
0,5000 1
MARITAL
0,3334 s
0,3334 m
0,3334 c
Rules
Root folder
Index
P act
Rule text
0 0,50000 STUDENT | YOUNG
1 0,50000 YOUNG | STUDENT
2 0,50000 YOUNG | MARITAL=s
3 0,50000 YOUNG | MARITAL=c
4 0,33333 MARITAL=s | (STUDENT ∧ PARENT)
5 0,33333 MARITAL=s | YOUNG

Step 2: Knowledge acquisition

Given

set of rules

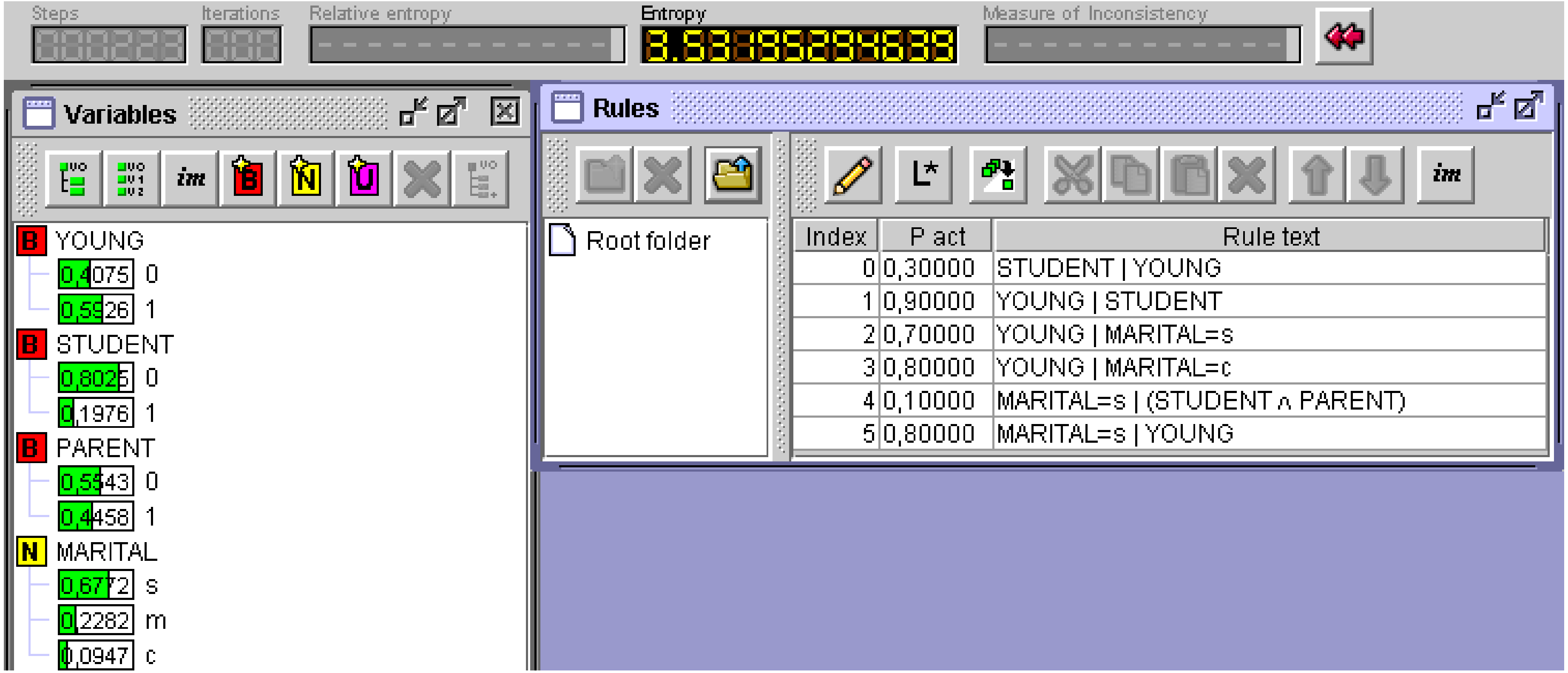
$\mathsf{R} = \{B_i|A_i\ [x_i],\ i=1,\ldots,I\}$.

Adaption of uniform distribution P^0 to R by solving

$$P^*=\arg\min R(Q, P^0), \quad \text{s.t. } Q \models \mathsf{R} \qquad (1)$$

$R(Q, P^0)$ relative entropy from P^0 to Q.

Excursus


Steps
Iterations
Relative entropy
Entropy
3.53385284639
Measure of Inconsistency
Variables
YOUNG
0,4075 0
0,5926 1
STUDENT
0,8025 0
0,1976 1
PARENT
0,5543 0
0,4458 1
MARITAL
0,6772 s
0,2282 m
0,0947 c
Rules
Root folder
Index | P act | Rule text
0 0,30000 STUDENT | YOUNG
1 0,90000 YOUNG | STUDENT
2 0,70000 YOUNG | MARITAL=s
3 0,80000 YOUNG | MARITAL=c
4 0,10000 MARITAL=s | (STUDENT ∧ PARENT)
5 0,80000 MARITAL=s | YOUNG

Step 3: Inference

Focus

$\mathsf{E} = \{D_j|C_j\ [y_j], j=1,\ldots,J\}$.

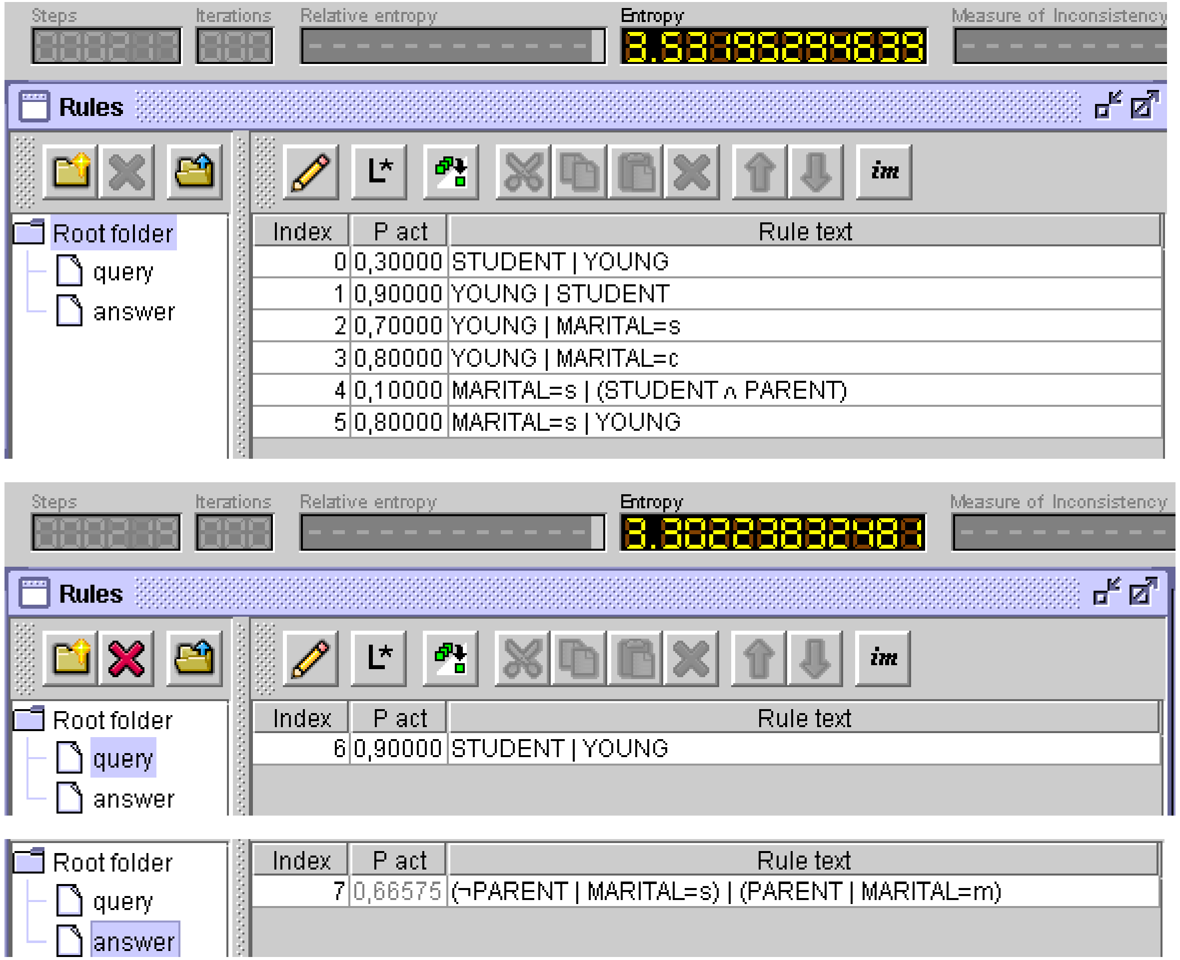
Adaption of P^* to E by solving

$$P^{**}=\arg\min R(Q, P^*), \quad \text{s.t. } Q \models \mathsf{E}. \qquad (2)$$

Query: $H|G$

Answer $P^{**}(H|G)$.

Excursus


Steps
Iterations
Relative entropy
Entropy
Measure of Inconsistency
Rules
Root folder
query
answer
Index | P act | Rule text
0 | 0,30000 | STUDENT | YOUNG
1 | 0,90000 | YOUNG | STUDENT
2 | 0,70000 | YOUNG | MARITAL=s
3 | 0,80000 | YOUNG | MARITAL=c
4 | 0,10000 | MARITAL=s | (STUDENT ∧ PARENT)
5 | 0,80000 | MARITAL=s | YOUNG
Steps
Iterations
Relative entropy
Entropy
Measure of Inconsistency
Rules
Root folder
query
answer
Index | P act | Rule text
6 | 0,90000 | STUDENT | YOUNG
Root folder
query
answer
Index | P act | Rule text
7 | 0,66575 | (¬PARENT | MARITAL=s) | (PARENT | MARITAL=m)

Reliability of answers

Given

P^*=arg min $R(Q, P^0)$, s.t. $Q \models$ R (1)

$H|G$ = ?

Lower bound

$\underline{u} = \min Q(H|G)$ s.t. $Q \models$ R and

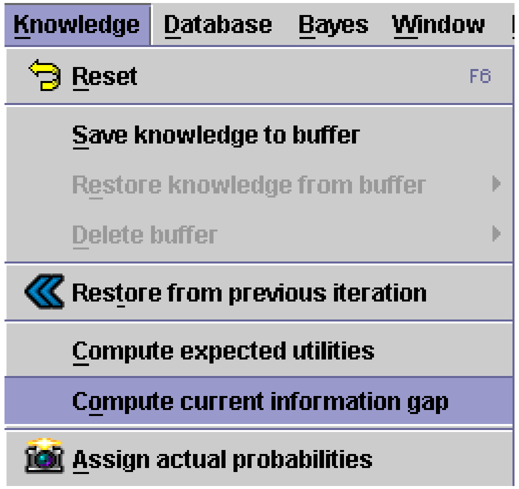
Upper bound

$\overline{u} = \max Q(H|G)$ s.t. Q $\models$ R.

Second order uncertainty of $H|G$

$m = -\mathrm{ld}\, \underline{u} - (-\mathrm{ld}\, \overline{u})$ [bit].

Excursus



Root folder
query

Act...	Index	P act	Rule text
✔	0	0,30000	STUDENT | YOUNG
✔	1	0,90000	YOUNG | STUDENT
✔	2	0,70000	YOUNG | MARITAL=s
✔	3	0,80000	YOUNG | MARITAL=c
✔	4	0,10000	MARITAL=s | (STUDENT ∧ PARENT)
✔	5	0,80000	MARITAL=s | YOUNG

Root folder
query

Act...	Index	P act	Rule text
✔	6	0,81271	YOUNG | (PARENT ∧ STUDENT)

Pmin: 0.0 Pmax: 0.999 I-gap: 26.5754 bit

Root folder
query

Acti...	Index	P act	Rule text
✔	0	0,30000	STUDENT | YOUNG
✔	1	0,90000	YOUNG | STUDENT
✔	2	0,70000	YOUNG | MARITAL=s
✔	3	0,80000	YOUNG | MARITAL=c
✔	4	0,10000	MARITAL=s | (STUDENT ∧ PARENT)
✔	5	0,80000	MARITAL=s | YOUNG
✔	7	0,22500	PARENT | STUDENT

Root folder
query

Act...	Index	P act	Rule text
✔	6	0,81271	YOUNG | (PARENT ∧ STUDENT)

Pmin: 0.555 Pmax: 0.999 I-gap: 0.8479 bit

Example creditworthiness

NB: No Bad earlier credits (t/f)

KN: client in KNown to the bank (t/f)

IN: INcome sufficient (t/f)

IA: Inquiry Agency (t/f)

GO: GOod credits (yes/no)

SU: somebody offers SUrety (t/f)

ME: financial MEans available (t/f)

JO: JOb for more than 3 years (t/f)

LO: LOan the money (t/f)

U: RetUrn of investment.

Index	P act	
0	0,87998	GO=yes
1	0,70000	SU | GO=yes
2	0,51000	SU | GO=no
3	0,65984	(IA ∧ KN) | GO=yes
4	0,39466	(IA ∧ KN) | GO=no
5	0,10000	(¬IA ∧ ¬KN) | GO=yes
6	0,34832	(¬IA ∧ ¬KN) | GO=no
7	0,23980	(IA ∧ ¬KN) | GO=yes
8	0,22119	(IA ∧ ¬KN) | GO=no
9	0,15005	(KN ∧ NB ∧ ME) | GO=yes
10	0,06011	(KN ∧ NB ∧ ME) | GO=no
11	0,11007	(KN ∧ ¬NB ∧ ME) | GO=yes
12	0,05010	(KN ∧ ¬NB ∧ ME) | GO=no
13	0,20012	(KN ∧ NB ∧ ¬ME) | GO=yes
14	0,16020	(KN ∧ NB ∧ ¬ME) | GO=no
15	0,19997	(KN ∧ ¬NB ∧ ¬ME) | GO=yes
16	0,16009	(KN ∧ ¬NB ∧ ¬ME) | GO=no
17	0,18002	(¬KN ∧ ¬NB ∧ ME) | GO=yes
18	0,21050	(¬KN ∧ ¬NB ∧ ME) | GO=no
19	0,43001	(IN ∧ ME) | GO=yes
20	0,33821	(IN ∧ ME) | GO=no
21	0,25006	(IN ∧ ¬ME) | GO=yes
22	0,19322	(IN ∧ ¬ME) | GO=no
23	0,24991	(¬IN ∧ ¬ME) | GO=yes
24	0,34298	(¬IN ∧ ¬ME) | GO=no
25	0,59000	JO | GO=yes
26	0,53000	JO | GO=no
27	1,00000	U=1466 | (LO=yes ∧ GO=yes)
28	1,00000	U=-8614 | (LO=yes ∧ GO=no)
29	1,00000	U=0 | (LO=no ∧ GO=no)
30	1,00000	U=-29 | (LO=no ∧ GO=yes)

Markov net

Given

set of finite valued variables $V = \{V_1,\ldots,V_L\}$.

With respect to $(V;P)$ if for any variable V_l, V_m:

$(V_l, V_m) \notin E \Leftrightarrow (V_l \perp V_m \mid V \setminus \{l,m\};P)$.

$\Rightarrow$ Minimal independency graph

Inference net

Given

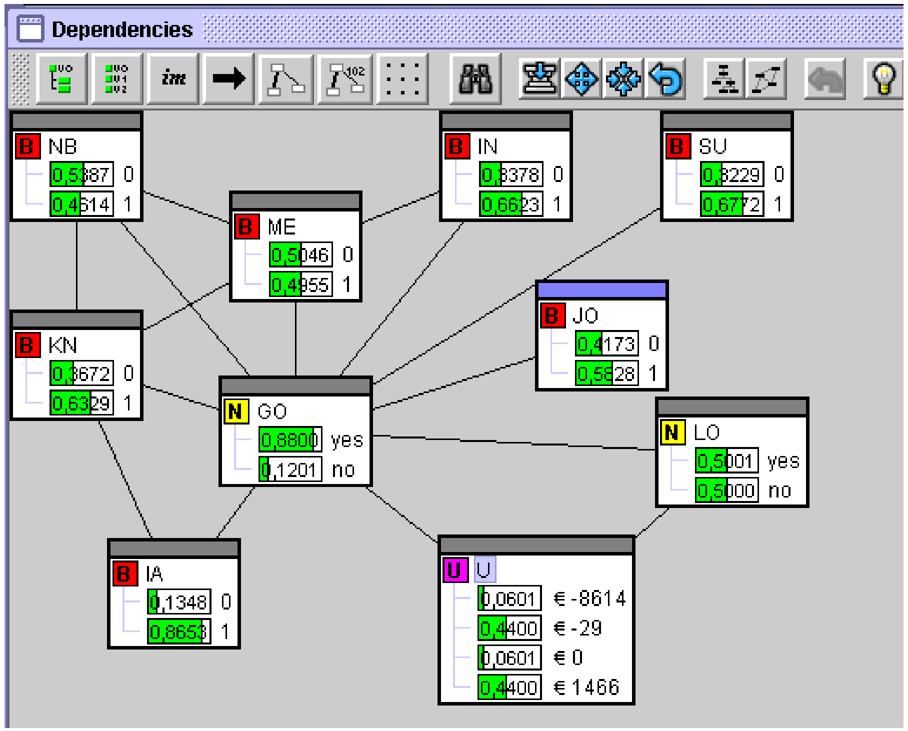
set of finite valued variables $V = \{V_1,\ldots,V_L\}$.

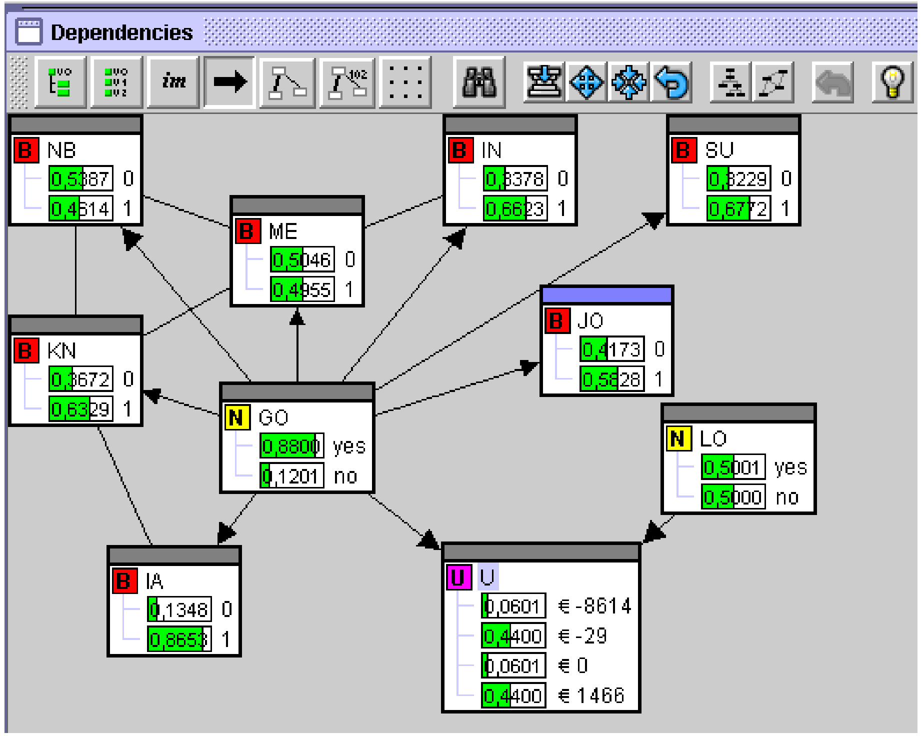
Variables V_l and V_m are involved in a rule $B_i|A_i$

V_l and V_m connected by an *arrow*, if a value v_l involved in A_i and v_m in B_i.

V_l and V_m connected by an *edge*, if v_l and v_m appear in the conclusion B_i of the same rule.

Excursus


Dependencies
B NB
0,5387 0
0,4614 1
B ME
0,5046 0
0,4955 1
B IN
0,3378 0
0,6623 1
B SU
0,3229 0
0,6772 1
B KN
0,3672 0
0,6329 1
B JO
0,4173 0
0,5828 1
N GO
0,8800 yes
0,1201 no
N LO
0,5001 yes
0,5000 no
B IA
0,1348 0
0,8653 1
U U
0,0601 € -8614
0,4400 € -29
0,0601 € 0
0,4400 € 1466


Dependencies
B NB
0,5387 0
0,4614 1
B ME
0,5046 0
0,4955 1
B IN
0,3378 0
0,6623 1
B SU
0,3229 0
0,6772 1
B KN
0,3672 0
0,6329 1
B JO
0,4173 0
0,5828 1
N GO
0,8800 yes
0,1201 no
N LO
0,5001 yes
0,5000 no
B IA
0,1348 0
0,8653 1
U U
0,0601 € -8614
0,4400 € -29
0,0601 € 0
0,4400 € 1466

Hypertree

Given

set of finite valued variables $V = \{V_1, \ldots, V_L\}$.

Denote $E_i(B_i|A_i) \subseteq V$ set of variables involved in a rule $B_i|A_i$

$\Rightarrow E_i$ hyperedges of the hypergraph $(V, \mathcal{E})$.

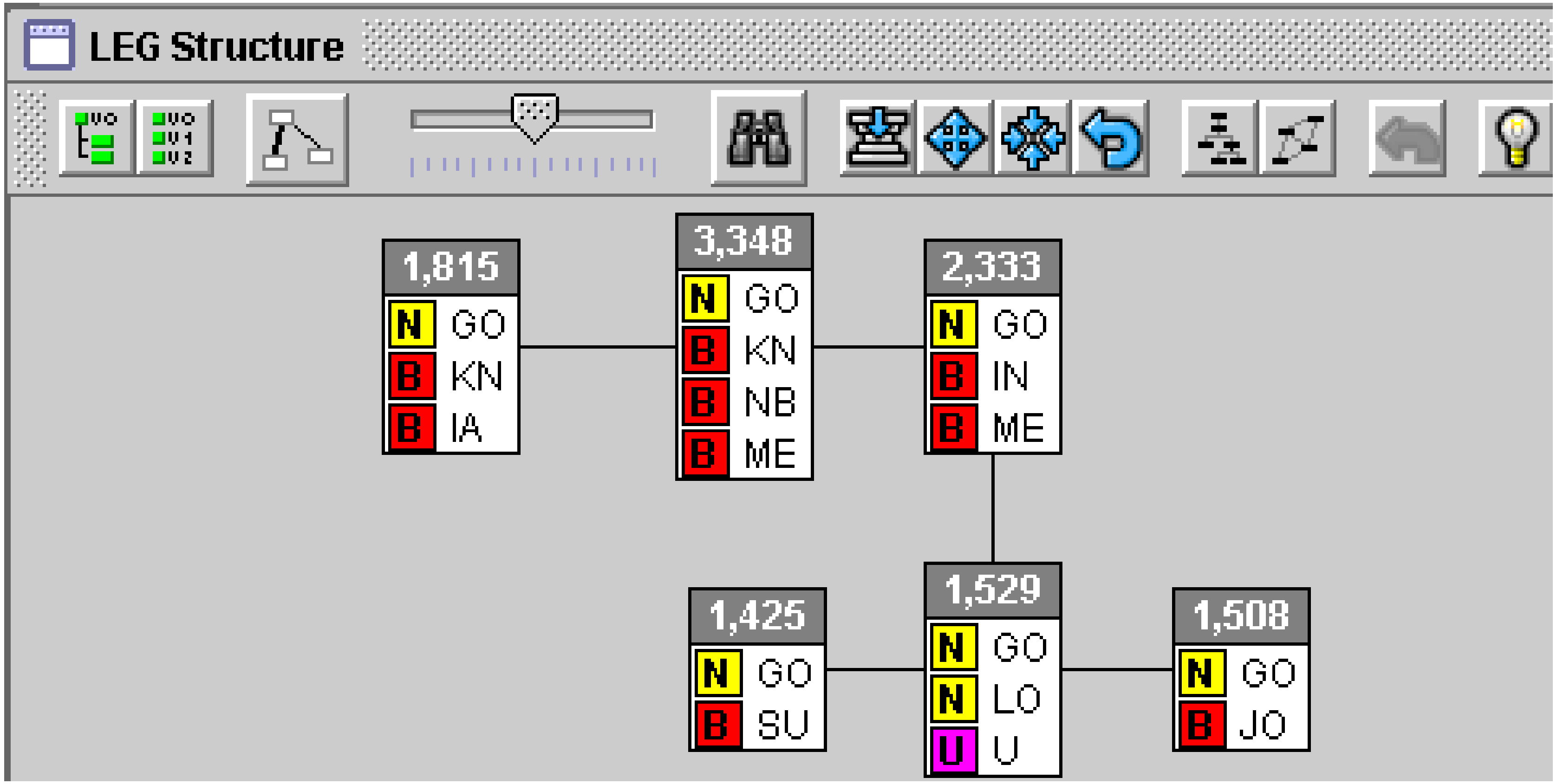
In general $(V, \mathcal{E})$ not acyclic,

use “fill-in”-methods to construct (acyclic) hypertree

For propagation: Hypertree $\Rightarrow$ junctiontree (each node

corresponds to an edge of the hypertree)

Excursus


LEG Structure
1,815
N GO
B KN
B IA
3,348
N GO
B KN
B NB
B ME
2,333
N GO
B IN
B ME
1,425
N GO
B SU
1,529
N GO
N LO
U U
1,508
N GO
B JO

Application credit worthiness

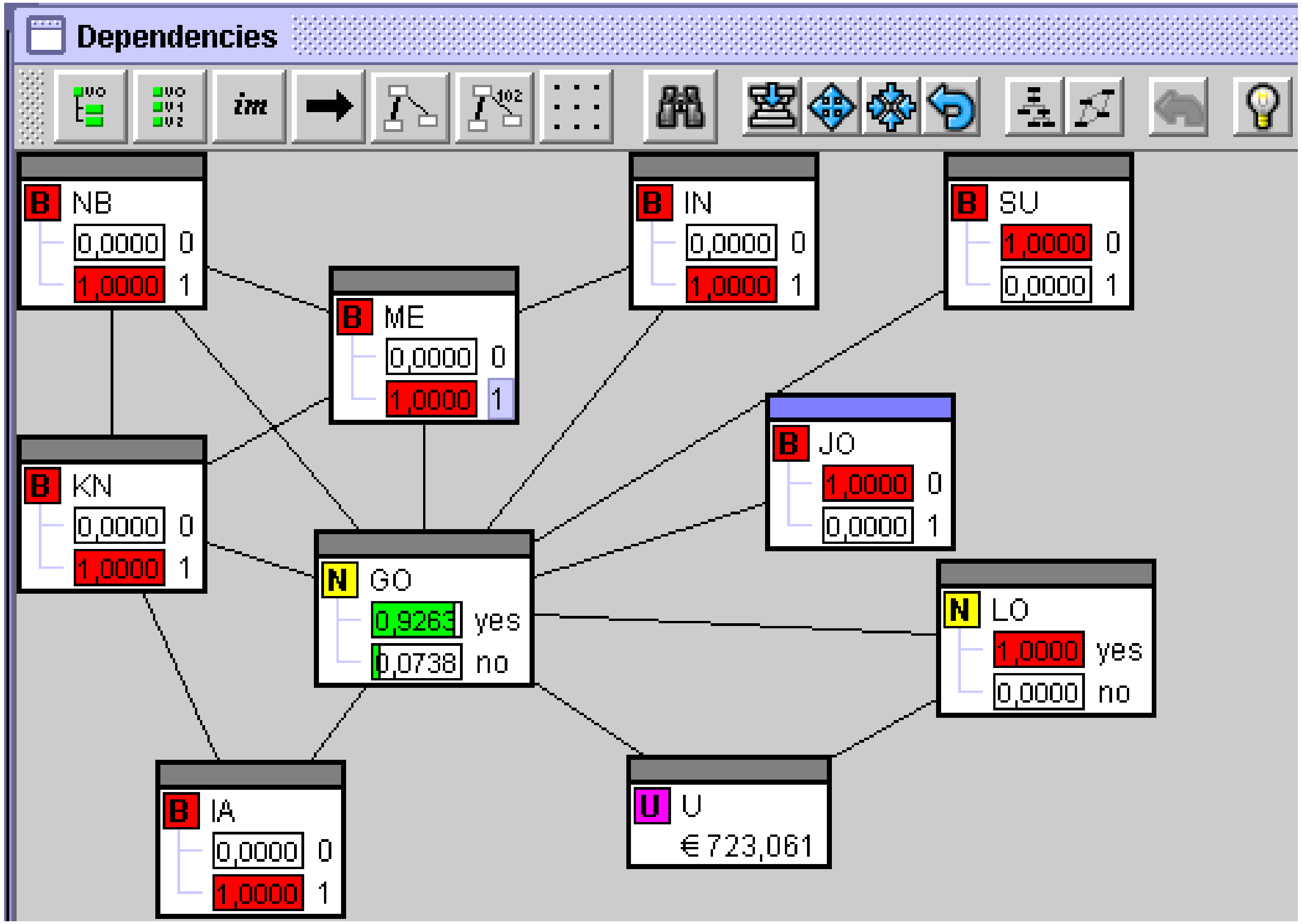
NB: No Bad earlier credits	**true**
KN: client in KNown to the bank	**true**
JO: JOb for more than 3 years (t/f)	**false**
SU: somebody offers SUrety (t/f)	**false**
ME: financial MEans available (t/f)	**true**
IN: INcome sufficient (t/f)	**true**
IA: Inquiry Agency (t/f)	**true**
LO: LOan the money (t/f)	**yes**
GO: GOod credits (yes/no)	**yes**

Amount of credits 10.000 €

Credit's lifespan: 4 years

U = 723,06 €

Excursus



Dependencies
NB
0,0000 0
1,0000 1
ME
0,0000 0
1,0000 1
IN
0,0000 0
1,0000 1
SU
1,0000 0
0,0000 1
JO
1,0000 0
0,0000 1
KN
0,0000 0
1,0000 1
GO
0,9263 yes
0,0738 no
LO
1,0000 yes
0,0000 no
IA
0,0000 0
1,0000 1
U
€ 723,061

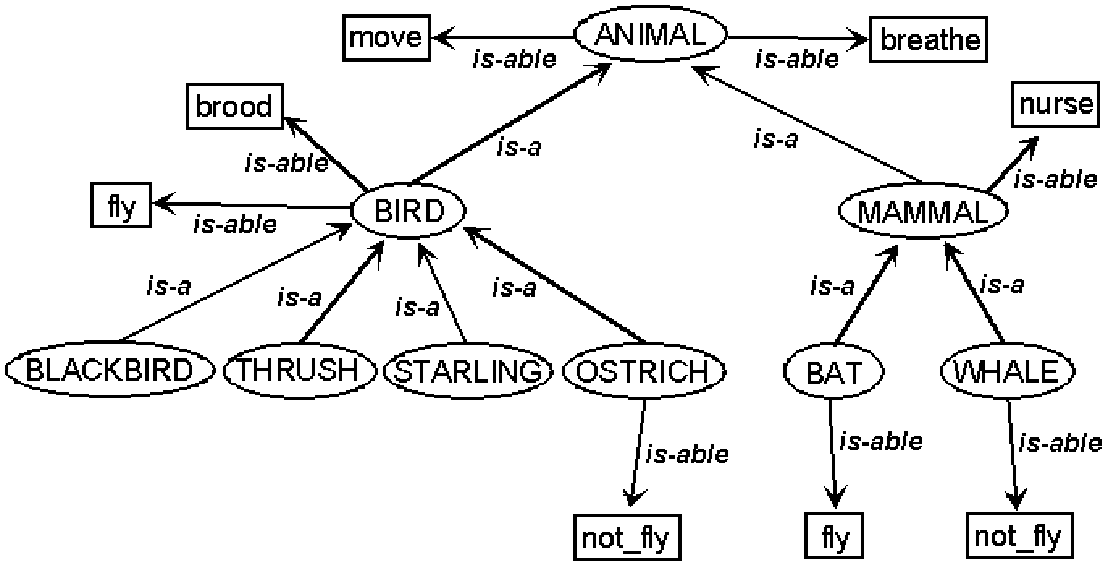
Recall by a stimulus

$V_l \in \{V_1,\ldots,V_L\}$,

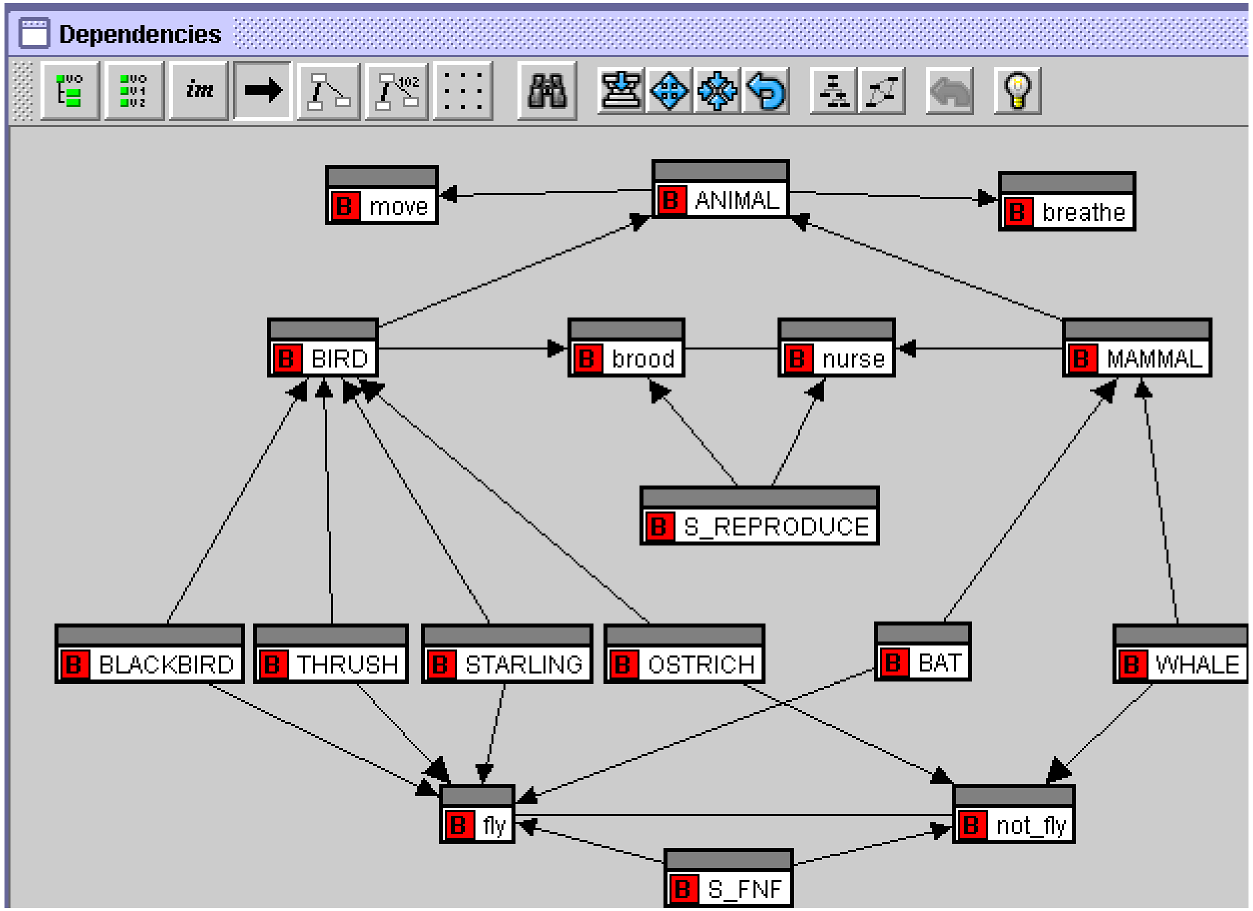
P^* epistemic state.

P^{**} adaption of P^* to a certain focus $\mathsf{E} = \{F\,[1.]\}$.

Impact measure: $R((V_l; P^{**}),(V_l; P^*))$ [bit].

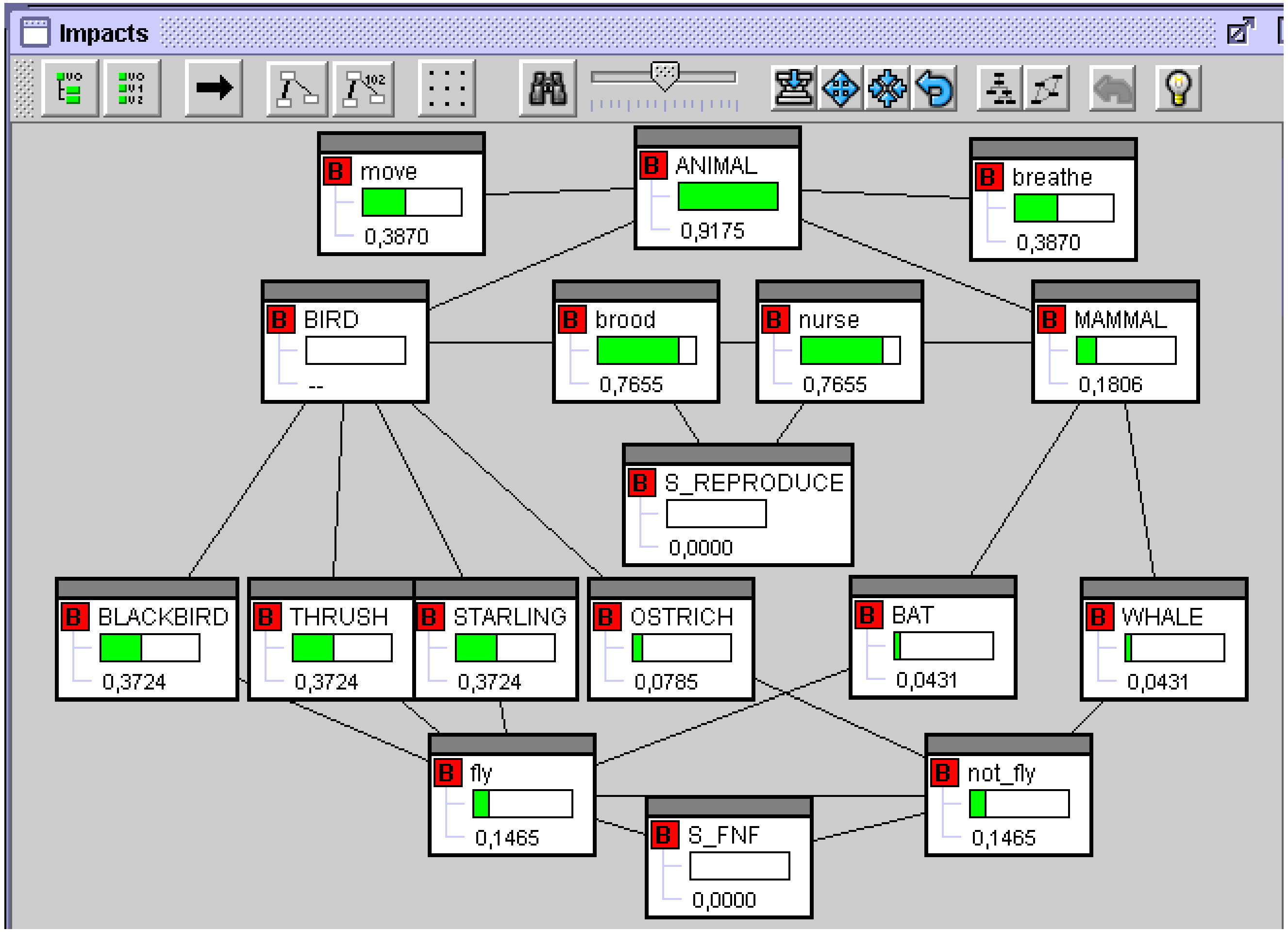


Excursus



Dependencies
move
ANIMAL
breathe
BIRD
brood
nurse
MAMMAL
S_REPRODUCE
BLACKBIRD
THRUSH
STARLING
OSTRICH
BAT
WHALE
fly
not_fly
S_FNF

Excursus



Impacts
move
0,3870
ANIMAL
0,9175
breathe
0,3870
BIRD
--
brood
0,7655
nurse
0,7655
MAMMAL
0,1806
S_REPRODUCE
0,0000
BLACKBIRD
0,3724
THRUSH
0,3724
STARLING
0,3724
OSTRICH
0,0785
BAT
0,0431
WHALE
0,0431
fly
0,1465
not_fly
0,1465
S_FNF
0,0000

Conclusion and remarks

Model	no. variables	no. rules	no. LEGs	$H(P^0)$	$H(P^*)$	utility yes/no	decision yes/no
BB	20	340	17	29.91	18.57	no	no
TS	76	574	50	76.00	12.83	no	yes
CR	18	38	13	22.68	6.00	no	no
BS	86	1051	36	104.79	87.12	no	yes
OD	6	18	3	8.17	4.08	yes	yes
CW	10	31	6	11.00	7.38	yes	yes

blue baby (BB) troubleshooter (TS)

car repair (CR) business-to-business (BS)

oil drilling problem (OD) credit worthiness support system (CW)