EPL - ECOLE POLYTECHNIQUE DE LOUVAIN

LINGI2261 - ARTIFICIAL INTELLIGENCE

Report of fourth assignement

Knapsack problem

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Contents

1   The Knapsack Problem

1.1   Diversification versus Intensification

Question 3 : Compare the 3 strategies on the given knapsack instances. Report in a table the results of the tests. Interesting metrics to report are: the computation time, the value of the best solution and the number of steps when the best result was reached (Node.step may be useful). A good way to eliminate the effect of the randomness of some of the strategies is to run the computation multiple times and take the mean value of the runs. For the first and the third strategy, each instance should be tested 10 times.

Level		0	1	2	3	4	5	6	7	8	9
	Time	627	185	178	244	316	294	347	471	404	450
Rw	Value	56.109	12.248	10.541	23.446	24.190	33.748	33.402	37.603	50.836	49.428
	Steps	72	66	61	9	73	86	18	24	74	9
	Time	201	124	124	147	173	150	178	217	175	213
Mv	Value	58.619	12.273	14.359	24.535	25.512	33.855	36.505	41.051	52.429	52.313
	Steps	5	5	8	4	6	8	9	10	7	7
	Time	214	132	132	142	169	156	179	219	184	224
Rmv	Value	62.124	14.888	15.283	24.704	33.748	33.855	37.885	42.315	54.694	53.328
	Steps	21	68	14	31	86	22	43	60	41	39

Question 4 : Answer the following questions :

   (a) What is the best strategy ?

   (b) Why do you think the best strategy beats the other ones ?

   (c) What are the limitations of each strategy in terms of diversification and intensification ?

(d) What is the behaviour of the different techniques when they fall in a local optimum ?

2   Propositional Logic

2.1   Models and logical connectives

Question 1 : For each sentence, give the number of models that satisfy it (considering the proposition variable A, B, C and D).

1. $(A \land B) \lor (\neg B \land C)$:

   Models :

A	B	C
V	V	V
V	V	F
V	F	V
F	V	V

2. $A \land \neg B$:

   Models :

A	B
V	F

3. $(A \Rightarrow B) \Leftrightarrow \neg C \lor \neg D$:

   Models :

A	B	C	D
V	V	V	F
V	V	F	V
V	V	F	F
V	F	V	V
F	V	V	F
F	V	F	V
F	V	F	F
F	F	V	F
F	F	F	V
F	F	F	F

2.2 RPG Equipment Problem

Question 1 : Explain how you can express this problem with propositional logic. What are the variables and how do you translate the relations and the query?

This problem could be divided in four relations :

Provides : $E \Rightarrow A$, this relation means that buying an object E allows the player to posses the ability A.

IsProvided : $A \Rightarrow E_1 \vee \ldots \vee E_n$, with $E_1, \ldots, E_n$ provide ability A, this relation means that the player must buy objects to posses abilities.

Conflicts : $\neg(E_1 \wedge E_2 \wedge E_3)$, this relation forbid the player to own more than two objects that are in conflict.

Requires : $A_i, \forall i$ such as A_i is needed to defeat an ennemy, this relation defines all abilities required to succeed the level.

Question 2 : Translate your model into Conjunctive Normal Form (CNF).

In CNF, our relations are quite easy to translate:

Provides : $\neg E \vee A$

IsProvided : $\neg \vee E_1 \vee \ldots \vee E_n$

Conflicts : $\neg E_1 \vee \neg E_2 \vee \neg E_3$

Requires : A

Question 4 : What is the output of your program when simulating the level $Level_05.gz$ with the merchant Merchant.gz ? How many variables and how many clauses did you generate to get this result (this should appearin the output of the minisat program which is displayed in the output of play.py)?

```
===========================[ Problem Statistics ]=============================
|                                                                            |
|  Number of variables:         4916                                         |
|  Number of clauses:          18916                                         |
|  Parse time:                  0.00 s                                       |
|                                                                            |
===========================[ Search Statistics ]==============================
| Conflicts |          ORIGINAL         |          LEARNT          | Progress |
|           |   Vars  Clauses Literals  |   Limit  Clauses Lit/Cl |          |
==============================================================================
==============================================================================
restarts              : 1
conflicts             : 0                    (-nan /sec)
decisions             : 1651                 (0.00 % random) (inf /sec)
propagations          : 4916                 (inf /sec)
conflict literals     : 0                    (-nan % deleted)
Memory used           : 20.00 MB
CPU time              : 0 s

SATISFIABLE
Equipment needed to beat the level 005
  - Lightning Eastern Armor
  - Iron Elite Cleric Gauntlets
  - Earth Smough's Gauntlets
  - Iron Smough's Armor
  - Water Leggings of Favor
  - Blood Mask of the Sealer
  - Fire Oolacile Ivory Catalyst
  - Air Black Sorcerer Gauntlets
  - Ice Sorcerer Gauntlets
  - Blood Paladin Leggings
  - Air Thorolund Talisman
  - Blood Black Tights
  - Lightning Royal Helm
  - Air Greatshield of Artorias
  - Earth Cleric Leggings
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          - Air Shotel
          - Ice Large Club
          - Blood Traveling Boots
          - Water Four-Pronged Plow
          - Lightning Zweihander
          - Fire Havel's Leggings
          - Lightning Gold-Hemmed Black Hood
          - Ice Greatsword of Artorias
          - Ice Bandit's Knife
     Total pieces of equipment needed: 24
```

Question 5 : Report in a table the number of clauses, variables and the number of equipment pieces needed when simulating the levels Level_005.gz , Level_050.gz ,Level_250.gz and Level_666.gz with Merchant.gz . How does the number of clauses, variables and pieces of equipment needed evolve with the size of thelevel? The number of a level represents the number of enemies it contains (e.g. Level_005.gz contains 5 enemies).

Level	Number of variables	Number of clauses	Pieces of equipment needed
Level 05	4.916	18.916	24
Level 50	4916	19.125	157
Level 250	4.916	19.796	377
Level 666	4.916	20.403	505

As the first tabular showed, the number of clauses doesn't seems to evolve a lot related to the increasing number of ennemies. As seen in figure 1, the average number of pieces of equipments or number of clauses decreases doesn't grow as fast as the number of ennemies. We can so compute larger models without having to care about computation time. We can explain it by the fact that even if there is only a single ennemy, the model still have to know all pieces from merchant and all conflicts or abilities related to them and this is the model main part.

Let's see the evolution of these parameters related to the number of ennemies :
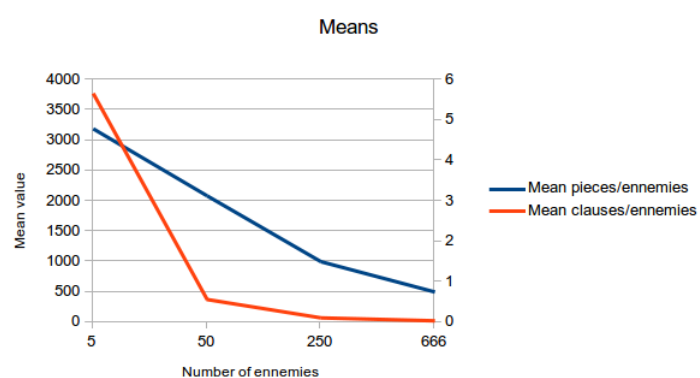

Figure 1: Orange line is related to the left Y axe and blue line is related to the right one.