EPL - ECOLE POLYTECHNIQUE DE LOUVAIN

LINGI2261 - ARTIFICIAL INTELLIGENCE

Report of fourth assignement

Knapsack problem

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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
Rw	Time	627	208	211	269	338	341	498	384	452	505
	Value	57.944	12.501	13.041	22.776	23.671	33.042	32.925	37.984	49.851	48.092
	Steps	75	86	92	6	16	33	14	2	21	2
Mv	Time	201	124	117	147	173	150	171	173	160	213
	Value	59.397	10.376	11.322	24.158	23.613	30.813	32.961	38.102	50.472	52.313
	Steps	1	1	1	1	1	2	2	1	2	2
Rmv	Time	245	132	136	142	169	156	179	204	175	219
	Value	62.124	15.235	15.283	24.704	25.950	33.855	37.885	40.695	52.271	52.548
	Steps	32	49	20	56	22	34	17	25	38	16

Question 4 : Answer the following questions :

(a) What is the best strategy ?

The best strategy is RANDOMIZED_MAXVALUE.

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

This strategy beats the other ones because it has less chances to reach a local optimum or to fall in bad branch.

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

Randomwalk : this strategy will search search in all successors. It's an advantage in terms of diversification. In terms of intensification, RANDOMWALK is very bad because it doesn't choose in particular branch to go deeper.

MaxValue : this strategy is the best in terms of intensification. It will choose a branch to go deeper in and will not try to reach other successors. It will a local optimum but the absolute one.

Randomized_Maxvalue : this strategy does a compromise between diversification and intensification. It has less chance to find a local optimum than MAXVALUE and more chance to find a maximum than RANDOMWALK.

(d) What is the behaviour of the different techniques when they fall in a local optimum ?
RANDOMWALK doesn't make any difference between being in a local optimum or not. MAXVALUE is stuck in this local optimum. RANDOMIZED_MAXVALUE has a few possibilities to avoid to be stuck in the local optimum. It is still less likely to fall in one.

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. $(A \wedge B) \vee (\neg B \wedge C)$:
   Models :

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

2. $A \wedge \neg B$:

   Models :

A	B
V	F

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

   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 $Level_0 5.gz$ 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 :

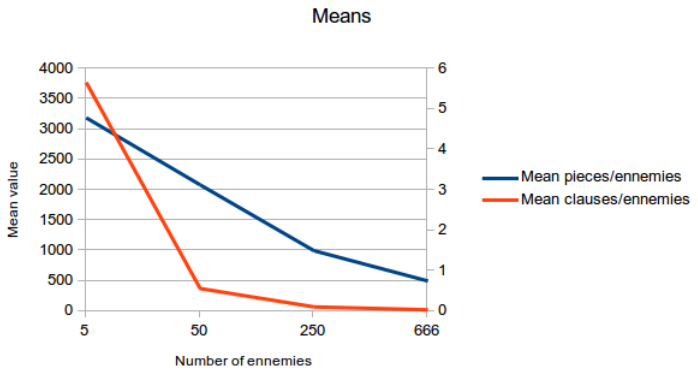

Figure 1: Orange line is related to the left Y axe and blue line is related to the right one.