Trabalho prático individual nº 1

Inteligência Artificial / Introdução à Inteligência Artificial
Ano Lectivo de 2017/2018

26 de Outubro de 2018

I Observações importantes

1. This assignment should be submitted via *Moodle* within 32 hours after the publication of this description. The assignment can be submitted after 32 hours, but will be penalized at 5% for each additional hour.

2. Complete the requested functions in module `"tpi1.py"`, provided together with this description. Keep in mind that the language adopted in this course is Python3.

3. Include your name and number and comment or delete non-relevant code (e.g. test cases, print statements); submit only the mentioned module `"tpi1.py"`.

4. You can discuss this assignment with colleagues, but you cannot copy their programs neither in whole nor in part. Limit these discussions to the general understanding of the problem and avoid detailed discussions about implementation.

5. Include a comment with the names and numbers of the colleagues with whom you discussed this assigment. If you turn to other sources, identify those sources as well.

6. All submitted code must be original; although trusting that most students will do this, a plagiarism detection tool will be used. Students involved in plagiarism will have their submissions canceled.

7. The submitted programs will be evaluated taking into account: performance; style; and originality / evidence of independent work. Performance is mainly evaluated concerning correctness and completeness, although efficiency may also be taken into acount. Performance is evaluated through automatic testing. If necessary, the submitted modules will be analyzed by the teacher in order to appropriately credit the student's work.

II Exercices

Together with this description, you can find module `tree_search`, similar to the one used in practical classes, with small changes and additions. In particular, some extra parameters were

added to the constructor of class SearchNode, which are stored without any processing. If needed, these parameters can be used to store additional data in the search tree.

The module `tpi1_tests` contains the Cidades class and the `cidades_portugal` search domain, which you already know. This domain is used for testing. The module already contains several tests. If needed, you can add other test code in this module.

Don't change the `tree_search` module. Module `tpi1` contains the classes TSP and MyTree. In the following exercices, you are asked to complete certain methods of these classes. All code that you are asked to develop should me integrated in the same module.

1. Create a search method search2() similar to the original method search() of class SearchTree, and add code to assign values to the following attributes of the search tree:

   - self . solution_cost - Total cost of the found solution.
   - self . tree_size - Total number of nodes of the generated tree.

   Example:

   ```
   >>> p = SearchProblem ( cidades_portugal , 'Beja' , 'Viseu' )
   >>> t1 = MyTree ( p , 'breadth' )
   >>> t1 . search2 ()
   [ 'Beja' , 'Evora' , 'Santarem' , 'Castelo Branco' , 'Viseu' ]
   >>> t1 . tree_size , t1 . solution_cost
   (185 , 561)
   ```

2. In SearchTree, implement methods `uniform_add_to_open()` and `astar_add_to_open()` to support the uniform cost and A* search strategies. These methods are already called in method `add_to_open()` of SearchTree. Add code in `search2()` to compute all the required information.

   Examples:

   ```
   >>> t2 = MyTree ( p , 'uniform' )
   >>> t2 . search2 ()
   [ 'Beja' , 'Evora' , 'Santarem' , 'Leiria' , 'Coimbra' , 'Viseu' ]
   >>> t2 . tree_size , t2 . solution_cost
   (285 , 469)

   >>> t3 = MyTree ( problems [0] , 'astar' )
   >>> t3 . search2 ()
   [ 'Beja' , 'Evora' , 'Santarem' , 'Leiria' , 'Coimbra' , 'Viseu' ]
   >>> t3 . tree_size , t3 . solution_cost
   (48 , 469)
   ```

3. To apply the `tree_search` module to solve problems in the "Blocks World", we would need to develop a new search domain to compute the state transitions. In particular, given a state and a STRIPS operator, we would need to determine all possible instanciations of the operator in that state. These instanciations are based on assignments of constants in the world to variables in the operator. Develop a function `assigments(lvars,lconsts)` in the `tpi1` module that, given a list with all variables in a certain operator and a list with all constants (e.g. blocks in the blocks world) in the current state, computes a list with all possible assignments of constants to variables. Each assignment takes the form of a dictionary.

   Example:

```
>>> assignments(['X','Y'],['a','b','c'])
[ {'X': 'a', 'Y': 'a'}, {'X': 'b', 'Y': 'a'}, {'X': 'c', 'Y': 'a'},
  {'X': 'a', 'Y': 'b'}, {'X': 'b', 'Y': 'b'}, {'X': 'c', 'Y': 'b'},
  {'X': 'a', 'Y': 'c'}, {'X': 'b', 'Y': 'c'}, {'X': 'c', 'Y': 'c'} ]
```

4. Develop a search domain, TSP, to solve instances of the following Travelling Salesman Problem formulation:

Given an inicial city and a list of other cities to visit, find a path that starts and ends in the initial city and passes only once in each of the other specified cities. The cities to visit are not necessarily adjacent, therefore it is acceptable to visit additional cities not in the given list. Domain information includes road connections between cities, respective distances and coordinates of cities.

In the TSP domain, each state will be a pair (lvisited,current), where current is the city where the travelling salesman is in a given moment and lvisited is a list with the sequence of cities he visited before.

Note that, as specified in the SearchDomain class (see the tree_search module), domains now have, in addition to the methods you already know, i.e. actions(s), result(s,a), cost(s,a) and heuristic(s,g), two additional methods:

- equivalent(s1,s2), which returns true if the two given states are equivalent.
- satisfies(state,goal), which returns true if the given goal is satisfied in the given state.

You have to implement these six methods for TSP. The object tsp_portugal is already created in tpi1_tests as an instance of TSP.

The following simple heristic (there are better ones ...) should be implemented: $CR + (n-1) * R + RL$, where CR is the minimum (straight line) distance from the current city to one of the remaining cities (not counting the initial/final city), n is the number of remaining cities, R is the minimum distance between pairs of remaining cities, and RL is the minimum distance from the initial/last city to one of the remaining distances.

Example:

```
>>> tsp_portugal.actions((['Aveiro'],'Porto')))
[ ('Porto', 'Agueda'), ('Porto', 'Aveiro'), ('Porto', 'Braga'),
  ('Porto', 'Guimaraes')]

>>> tsp_portugal.result((['Aveiro'],'Porto'),('Porto','Braga')))
(['Aveiro', 'Porto'], 'Braga')

>>> tsp_portugal.cost((['Aveiro'],'Porto'),('Porto','Braga')))
57

>>> tsp_portugal.actions((['Aveiro','Porto'],'Aveiro'))
[]

>>> tsp_portugal.actions((['Aveiro','Porto'],'Agueda')))
[('Agueda', 'Aveiro'), ('Agueda', 'Coimbra'), ('Agueda', 'Viseu')]

>>> tsp_portugal.heuristic(([],'Porto'),(['Porto','Coimbra','Viseu'],'Porto'))
227.9228618619931
```

```
>>> tsp_portugal.equivalent( (['Porto','Aveiro','Agueda'],'Coimbra'),
                             (['Porto','Agueda','Aveiro'],'Coimbra') ))
True

>>> tsp_portugal.satisfies( (['Porto','Aveiro','Coimbra','Agueda'],'Porto'),
                            (['Porto','Coimbra'],'Porto') )
True


>>> p = formulateTSP(tsp_portugal,'Porto', \
                ['Agueda','Aveiro','Guimaraes','Viseu'])
>>> solveTSP(p,'breadth'))
( [ 'Porto', 'Aveiro', 'Agueda', 'Viseu', 'Lamego', 'Guimaraes', 'Porto' ],
   1249, 370 )


>>> q = formulateTSP(tsp_portugal,'Porto',['Aveiro','Guimaraes','Viseu'])
>>> solveTSP(q,'uniform')
( [ 'Porto', 'Guimaraes', 'Lamego', 'Viseu', 'Agueda', 'Aveiro', 'Porto' ],
   511, 370 )

>>> r = formulateTSP(tsp_portugal,'Porto',['Evora','Aveiro','Santarem','Viseu'])
>>> solveTSP(r,'astar')
( [ 'Porto', 'Aveiro', 'Coimbra', 'Leiria', 'Santarem', 'Evora',
    'Portalegre', 'Castelo Branco', 'Covilha', 'Viseu', 'Agueda', 'Porto'],
   4177, 950 )
```

III Clarification of doubts

This work will be followed through `http://detiuaveiro.slack.com`. The clarification of the main doubts will be placed here.

1. (16h38) The definition of the heuristic for the last exercice was improved and the example was updated with the new results for the heuristic and A*.

2. Os resultados das soluções do exercício 1 e 2 apresentados no pdf só funcionam se *não* evitarmos ciclos. É suposto deixarmos?

   Resposta: Sim, não afecta o trabalho. Não vamos usar pesquisa em profundidade.