CS 161: Fundamentals of Artificial Intelligence

Spring 2025 — Assignment 2 — Due 11:59pm, Tuesday, April 15

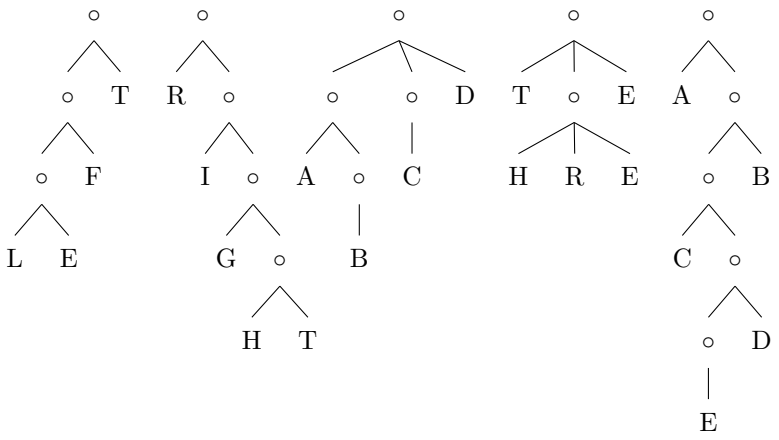
- Submit your commented Python program in a file named **hw2.py** via **Gradescope**.
- Base your solution on the skeleton file named **hw2-skeleton.py**.
- Your programs should be written in good style. In Python, a comment is any character following a hash character (#) on a line. Provide an overall comment explaining your solutions. Furthermore, every function should have a header comment explaining precisely what its arguments are, and what value it returns in terms of its arguments. In addition, you should use meaningful variable names.
- The physical layout of the code on the page is very important for making python programs readable. Make sure that you use blank lines between functions and indent properly. Programming style will be a consideration in grading the assignment.
- You are restricted to using the python built-in functions. All other packages made by `import` (like `numpy` `queue`, and `collections`) are forbidden.
- You may assume that all input to your functions is legal; i.e. you do not need to validate inputs.
- Do not write any additional helper functions for your code unless this is explicitly allowed.
- Your function declarations should look **exactly as specified** in this assignment. Make sure the functions are spelled correctly, take the correct number of arguments, and those arguments are in the correct order.
- Even if you are not able to implement working versions of these functions, please **include a correct skeleton** of each. Some of these assignments are auto graded and having missing functions is problematic.
- By submitting this homework, you agree to the honor code stated in HW1.

1. (20pts) A search tree can be represented as *tuples* in Python as follows:

(a) if the search tree contains a single leaf node L, it can be represented by a non-tuple object `L`

(b) if the search tree has more than one node and is rooted at N, then it can be represented by a tuple `(S1, S2, ... Sk)` where `Si` represents the ith subtree of N.

Consider for example the following search trees, whose Python representations are shown later.



Write a single Python function, called `BFS`, that takes a single argument `TREE` that represents a tree, and returns a tuple of leaf nodes in the order they are visited by **left-to-right** breadth-first search. Test your program on at least these inputs:

```
>>> BFS("ROOT")
('ROOT',)
>>> BFS((("L", "E"), "F"), "T"))
('T', 'F', 'L', 'E')
>>> BFS(("R", ("I", ("G", ("H", "T")))))
('R', 'I', 'G', 'H', 'T')
>>> BFS((("A", ("B",)), ("C",), "D"))
('D', 'A', 'C', 'B')
>>> BFS(("T", ("H", "R", "E"), "E"))
('T', 'E', 'H', 'R', 'E')
>>> BFS(("A", (("C", (("E",), "D")), "B")))
('A', 'B', 'C', 'D', 'E')
```

2. (20pts) Write a single Python function, called `DFS`, that takes a single argument `TREE` that represents a tree, and returns a tuple of leaf nodes in the order they are visited by **left-to-right** depth-first search. Test your program on at least these inputs:

```
>>> DFS("ROOT")
('ROOT',)
>>> DFS((("L", "E"), "F"), "T"))
('L', 'E', 'F', 'T')
>>> DFS(("R", ("I", ("G", ("H", "T")))))
('R', 'I', 'G', 'H', 'T')
>>> DFS((("A", ("B",)), ("C",), "D"))
```

```
('A', 'B', 'C', 'D')
>>> DFS(("T", ("H", "R", "E"), "E"))
('T', 'H', 'R', 'E', 'E')
>>> DFS(("A", (("C", (("E",), "D")), "B")))
('A', 'C', 'E', 'D', 'B')
```

3. (20pts) Write a **set** of Python functions that implement depth-first iterative-deepening search. The top-level function, called `DFID`, takes two arguments, a tuple `TREE` representing a tree and an integer `D` representing the depth of `TREE`, and returns a tuple of leaf nodes in the order they are visited by a **right-to-left** depth-first iterative-deepening search. Note that those nodes that are visited in multiple iterations will appear multiple times in the returned tuple. Test your program on at least these inputs:

```
>>> DFID("ROOT", 0)
('ROOT',)
>>> DFID((("L", "E"), "F"), "T"), 3)
('T', 'T', 'F', 'T', 'F', 'E', 'L')
>>> DFID(("R", ("I", ("G", ("H", "T")))), 4)
('R', 'I', 'R', 'G', 'I', 'R', 'T', 'H', 'G', 'I', 'R')
>>> DFID((("A", ("B",)), ("C",), "D")), 3)
('D', 'D', 'C', 'A', 'D', 'C', 'B', 'A')
>>> DFID(("T", ("H", "R", "E"), "E"), 2)
('E', 'T', 'E', 'E', 'R', 'H', 'T')
>>> DFID(("A", (("C", (("E",), "D")), "B")), 5)
('A', 'B', 'A', 'B', 'C', 'A', 'B', 'D', 'C', 'A', 'B', 'D', 'E', 'C', 'A')
```

4. (40pts) This question aims to solve a problem stated by Homer Simpson in *"Gone Maggie Gone"*, The Simpsons, Season 20, Episode 13. Homer wants to cross a river with his baby (Maggie), his dog (Santa's Little Helper), and a jar of poison. Homer is the only one who can operate the boat, and he can take at most one thing with him. The dog cannot be left alone with the baby, because he tries to bite her. The baby cannot be left alone with the poison, because she tries to eat it. The goal is to get everybody on the other side of the river.

The file **hw2-skeleton.py** contains a framework for solving this puzzle using depth-first search. Implement the functions in it as described in the comments. **DO NOT CHANGE THE FUNCTION NAMES OR PARAMETERS. DO NOT WRITE ANY ADDITIONAL FUNCTIONS**.