Practical 3

aim :climbing algorithm implemented on Tree of nodes

Theory : Simple hill climbing is the simplest way to implement a hill climbing algorithm. It only

evaluates the neighbor node state at a time and selects the first one which optimizes current cost and set it as a current state. It only checks it's one successor state, and if it finds better than the current state, then move else be in the same state

```
class Node:
  """A simple node """
  def __declare_instance_variables(this) -> None:
    this.parent: Node = None
    this.root: Node = None
    this.__children: list = []
  def __init__(this, child = None, children: list = None, value: float = None, tag:
    """child: Node, children: List[Node]"""
    this.__declare_instance_variables()
    this.tag = tag
    this.value = value
    if (child != None):
      this.add(child)
    if (children != None):
      this.add_children(children)

  def get_neighbors(this) -> list:
    """Returns the neighbor nodes"""
    if this.parent == None:
      return [this]
    children = this.parent.get_children()
    if children == None:
      return []
    return children

  def get_first(this):
    """Returns the first children of this node"""
    if (this.is_empty): return None
    return this.__children[0]

  def is_root(this) -> bool:
    return this.parent == None

  def is_leaf(this) -> bool:
    if (this.__children == None): return True
    return this.is_empty()
```

```
  def is_inner(this) -> bool:
    return not (this.is_leaf() or this.is_root())

  def get_children(this) -> list:
    return this.__children

  def get_root(this):
    """Returns -> Node"""
    if (this.is_root()):
      return this
    else:
      return this.parent.root

  def get_height(this) -> int:
    if (this.is_empty()):
      return 0
    maxHeight: int = 0
    children: list = this.get_children()
    for element in children:
      height: int = element.get_height()
      if (height > maxHeight):
        maxHeight = height
    return maxHeight + 1

  def get_depth(this) -> int:
    if (this.is_root()):
      return 0
    return this.parent.get_depth() + 1

  def is_empty(this) -> bool:
    return len(this.__children) == 0

  def is_not_empty(this) -> bool:
    return not this.is_empty()

  def add(this, child) -> None:
    """child: Node"""
    assert child != None
    if (this.__children == None):
      this.__children = []
    child.parent = this
    child.root = this.get_root()
    this.__children.append(child)

  def add_children(this, children: list) -> None:
    assert children != None
    if (len(children) == 0):
      return
    if (this.__children == None):
      this.__children = []
    for element in children:
      element.parent = this
      element.root = this.get_root()
      this.__children.append(element)
```

```
  def __len__(this) -> int:
    if (len(this.__children) != 0 and this.__children != None):
      maxLength: int = 1
      for child in this.__children:
          maxLength += len(child)
      return maxLength
    else:
      return 1
  def __str__(this) -> str:
    return f"Node({this.value})"


def node_to_string(node: Node, islast=False):
  pretab = '' if node.get_depth() == 0 else ' ' * (node.get_depth())
  prefix = f'{pretab}:{node.get_depth()} ——'
  value = node.value
  depthTab: str = ' ' * (node.get_depth() + 1)
  children_str = ''
  for child in node.get_children():
    ischildlast = node.get_children()[-1] == child
    children_str += f'{depthTab}{node_to_string(child, ischildlast)}'
  return (
      f'{prefix} {node.tag} = {value}\n'
      f'{children_str}'
  )


def evaluate(node: Node):
  """returns the value of the node"""
  if(isinstance(node.value, float) or isinstance(node.value, int)):
    assert node.value != None, "Node must have a value"
    return node.value
  elif(isinstance(node.value, str)):
    raise NotImplementedError
```

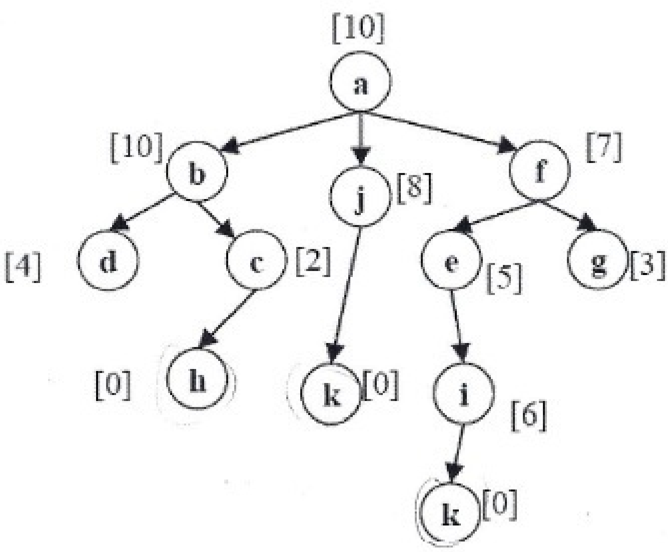
Simple hill climbing algorithm

```
from math import inf
def hill_climbing(start_node) -> Node:
  """
  Pseudo-code for the algorithm

  ```
  algorithm hill Climbing is
      currentNode := startNode
      loop do
          L := NEIGHBORS(currentNode)
          nextEval := −INF
          nextNode := NULL
          for all x in L do
              if EVAL(x) > nextEval then
                  nextNode := x
```
```

```
                nextEval := EVAL(x)
        if nextEval ≤ EVAL(currentNode) then
            // Return current node since no better neighbors exist
            return currentNode
        currentNode := nextNode
```
```
  """
  current_node = start_node
  best_value = -inf
  best_node = None
  while True:
    current_value = evaluate(current_node)
    if current_value > best_value:
      best_node = current_node
      best_value = current_value
    else:
      # this node has a value smaller than the best node.
      # stopping search with local maxima
      return best_node
    childrens = current_node.get_children()
    for child in childrens:
      child_value = evaluate(child)
      if child_value > best_value:
        best_value = child_value
        best_node = child
      else:
        return best_node
      # every neighbour of this child is traversed.
      # Setting current_node as the last child traversed
      current_node = child
```

Tree - 1 on which the algorithm will perform to find the best possible solution




```
# implemented the above tree of nodes
```

```
tree1: Node = Node(
    value=10, tag='a',
    children=[
        Node(
            value=10, tag='b',
            children=[
                Node(value=4, tag='d'),
                Node(value=2, tag='c',
                     child=Node(value=0, tag='h')
                ),
            ]
        ),
        Node(value=8, tag='j',
            child=Node(value=0, tag='k')
        ),
        Node(value=7, tag='f',
            children=[
                Node(value=5, tag='e',
                    child=Node(
                        value=6, tag='i',
                        child=Node(value=0, tag='k')
                    )
                ),
                Node(value=3, tag='g')
            ]
        )
    ]
)


#·implemented·an·another·tree·of·nodes
tree2:·Node·=·Node(
····value=2,·tag='a',
····children=[
········Node(
············value=4,·tag='b',
············children=[
················Node(value=5,·tag='d'),
················Node(value=6,·tag='c',
·····················child=Node(value=8,·tag='h')
················),
············]
········),
········Node(value=9,·tag='j',·
············child=Node(value=0,·tag='k')
········),
········Node(value=7,·tag='f',
············children=[
················Node(value=12,·tag='e',·
····················child=Node(
························value=6,·tag='i',·
························child=Node(value=0,·tag='k')
····················)
················),
················Node(value=3,·tag='g')
```

```
            ]
        )
    ]
)
```

```
print('Tree - 1: representation')
print('pattern -> :<depth> ─── <value>', end='\n\n')
print(node_to_string(tree1))
```

```
Tree - 1: representation
pattern -> :<depth> ─── <value>

:0 ─── a = 10
  :1 ─── b = 10
    :2 ─── d = 4
    :2 ─── c = 2
      :3 ─── h = 0
  :1 ─── j = 8
    :2 ─── k = 0
  :1 ─── f = 7
    :2 ─── e = 5
      :3 ─── i = 6
        :4 ─── k = 0
    :2 ─── g = 3
```

```
print('Tree - 2: representation')
print('pattern -> :<depth> ─── <value>', end='\n\n')
print(node_to_string(tree2))
```

```
Tree - 2: representation
pattern -> :<depth> ─── <value>

:0 ─── a = 2
  :1 ─── b = 4
    :2 ─── d = 5
    :2 ─── c = 6
      :3 ─── h = 8
  :1 ─── j = 9
    :2 ─── k = 0
  :1 ─── f = 7
    :2 ─── e = 12
      :3 ─── i = 6
        :4 ─── k = 0
    :2 ─── g = 3
```

```
print('For Tree - 1')
best_solution = hill_climbing(tree1)
print(f"Best solution is {best_solution.value} with tag {best_solution.tag}")
```

```
For Tree - 1
Best solution is 10 with tag a
```

```
print('For Tree - 2')
```

```
print("For·Tree·-·2")
best_solution·=·hill_climbing(tree2)
print(f"Best·solution·is·{best_solution.value}·with·tag·{best_solution.tag}")
```

```
For Tree - 2
Best solution is 9 with tag j
```