**PS4**

**1- Uninformed state-space search (6pts)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | 6 | 5 | 8 |  |  |  |  |  |  |
|  |  |  |  |  |  | 7 | \_ | 1 |  |  |  |  |  |  |
|  |  |  |  |  |  | 3 | 4 | 2 |  |  |  |  |  |  |
| 2 |  |  |  | 3 |  |  |  | 4 |  |  |  | 5 |  |  |
| 6 | 5 | 8 |  | 6 | 5 | 8 |  | 6 | \_ | 8 |  | 6 | 5 | 8 |
| \_ | 7 | 1 |  | 7 | 1 | \_ |  | 7 | 5 | 1 |  | 7 | 4 | 1 |
| 3 | 4 | 2 |  | 3 | 4 | 2 |  | 3 | 4 | 2 |  | 3 | \_ | 4 |
| 6 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 | 5 | 8 |  |  |  |  |  |  |  |  |  |  |  |  |
| 7 | \_ | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | 4 | 2 |  |  |  |  |  |  |  |  |  |  |  |  |

**a. Breadth first search**

**b. Depth first search**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  | 1 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 6 | 5 | 8 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 7 | \_ | 1 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  | 3 | 4 | 2 |  |  |  |  |  |  |
|  |  |  |  | 2 |  |  |  | 6 |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | 6 | 5 | 8 |  | 6 | 5 | 8 |  |  |  |  |  |  |  |  |
|  |  |  |  | \_ | 7 | 1 |  | 7 | 1 | \_ |  |  |  |  |  |  |  |  |
|  |  |  |  | 3 | 4 | 2 |  | 3 | 4 | 2 |  |  |  |  |  |  |  |  |
| 3 |  |  |  | 4 |  |  |  | 5 |  |  |  |  |  |  |  |  |  |  |
| 6 | 5 | 8 |  | \_ | 5 | 8 |  | 6 | 5 | 8 |  |  |  |  |  |  |  |  |
| 7 | \_ | 1 |  | 6 | 7 | 1 |  | 3 | 7 | 1 |  |  |  |  |  |  |  |  |
| 3 | 4 | 2 |  | 3 | 4 | 2 |  | \_ | 4 | 2 |  |  |  |  |  |  |  |  |

**c. Iterative deepening search**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | 1 | & | 2 |  |  |  |  |  |  |
|  |  |  |  |  |  | 6 | 5 | 8 |  |  |  |  |  |  |
|  |  |  |  |  |  | 7 | \_ | 1 |  |  |  |  |  |  |
|  |  |  |  |  |  | 3 | 4 | 2 |  |  |  |  |  |  |
| 3 |  |  |  | 4 |  |  |  | 5 |  |  |  | 6 |  |  |
| 6 | 5 | 8 |  | 6 | 5 | 8 |  | 6 | \_ | 8 |  | 6 | 5 | 8 |
| \_ | 7 | 1 |  | 7 | 1 | \_ |  | 7 | 5 | 1 |  | 7 | 4 | 1 |
| 3 | 4 | 2 |  | 3 | 4 | 2 |  | 3 | 4 | 2 |  | 3 | \_ | 4 |

**2- Determining the depth of a node (12pts)**

1. **Time complexity of binary tree**

Tree of n nodes.

**Best case:**

key is the root

key == root.key at first recursive call.

Time complexity: O(1)

**Worst case:**

key is not in the tree.

balanced tree:

we have to visit all the nodes

time complexity: O(n)

unbalanced tree:

equivalent to a linked list, and we have to visit all the list.

time complexity: O(n)

1. **Revised depthInTree()**

**private** **static** **int** **depthInTree** (**int** key, Node root) {

**if** (key == root.key)

**return** 0;

**if** (root.left != **null** && key < root.key){

**int** depthInLeft = **depthInTree** (key, root.left);

**if** (depthInLeft != -1)

**return** depthInLeft + 1;

}

**if** (root.right != **null** && key >= root.key) {

**int** depthInRight = **depthInTree** (key, root.right);

**if** (depthInRight != -1)

**return** depthInRight + 1;

}

**return** -1;

}

1. **Time complexity of binary SEARCH tree**

Tree of n nodes.

**Best case:**

key is the root

key == root.key at first recursive call.

Time complexity: O(1)

**Worst case:**

key is not in the tree.

balanced tree:

we divide the problem in 2 at each recursion

time complexity: O(log2n)

unbalanced tree:

equivalent to a linked list, and we have to visit all the list.

time complexity: O(n)

**3- Tree traversal puzzle (10pts)**

1. **inorder: SKBPCJRDME, preorder: PSBKRJCMDE**
2. **postorder: IBGOZKHNSL, preorder: LOGIBSHKZN**

**4- Huffman encoding (7pts)**

|  |  |
| --- | --- |
| **Ch** | **Fq** |
| F | 8 |
| C | 14 |
| O | 17 |
| I | 20 |
| E | 40 |

1. **Huffman tree**
2. **Encoding of a string**

From the tree, we get the following encoding:

**O = 00**

**F = 110**

**I = 01**

**C = 111**

**E = 10**

Therefore: **office = 00 110 110 01 111 10**

**5- Binary search trees (10pts)**

1. **preorder, at right**

28, 53, 62, 80

1. **post order**

28, 23, 35, 48, 57, 80, 62, 53, 44

1. **insert 25, insert 51**
2. **delete 53, delete 35**
3. **balanced tree**

The original tree **is not** balanced because:

The right subtree of 35 has a 0 height.

The left subtree of 35 has a 2 height.

They differ by more than 1. Therefore, the tree is not balanced.

**6- 2-3 trees and B-Trees (10pts)**

keys: A, D, G, B, F, C, H, I, E, J

1. **empty 2-3 tree**

**1- insert A**

**2- insert D**

**3- insert G**

**split**

**4- insert B**

**5- insert F**

**6- insert C**

**split**

**7- insert H**

**split**

**split**

**8- insert I**

**9- insert E**

**10- insert J**

**split**

1. **empty B-tree of order 2**

**1- insert A**

**2- insert D**

**3- insert G**

**4- insert B**

**5- insert F**

**split**

**6- insert C**

**7- insert H**

**8- insert I**

**9- insert E**

**split**

**10- insert J**