Intro

November 8, 2021

1 Algorithms and Data Structures

1.1 Why

1. Helps you to practice.
2. Basic concepts and ideas that you will se again and again.
3. Solving these problems can help you solve bigger problems.
4. Builds confidence.
5. Rehersal for technical interviews.
6. Helps understand how more advance software works.
7. General Knowledge of programming.
8. Forces you to try to solve a problem step by step.
9. You need to be able to communicate ideas.
10. Convert ideas into code.
11. You need to think about inputs, outputs, test cases and edge cases.

2 Algorithms

It is a finite sequence of well defined steps to solve a specific problem.

2.1 Steps to solve a problem

1. We have to define the problem with very clear language.
2. Think about possible data scenarios.
3. Define solution for the problem.
4. Implement the solution in your language of preference.
5. Test solution and use cases.
6. Analyze algorithm's complexity and performance.
7. Find a better solution, if possible.

2.1.1 Problem definition

Given a sorted list of number find a the location of a given number in that list.

2.1.2 Data scenarios

The following are some examples of data input for the problem

[1]:
```
numbers=[1,3,7,13,21,45,67,89]
search=45
result=5
```

2.1.3 First solution

[2]:
```
def find_number_linear(numbers, search):
    for i in range(len(numbers)):
        if numbers[i]==search:
            return i;
    return -1
```

[3]:
```
find_number_linear(numbers,search)==result
```

[3]:
```
True
```

2.1.4 Validation as Dictionary

[4]:
```
validation= {
    'data':{
        'numbers': [1,3,7,13,21,45,67,89],
        'search': 45
    },
    'result' : 5,
    'description':'Simple test'
}
```

[5]:
```
find_number_linear(**validation['data']) == validation['result']
```

[5]:
```
True
```

2.1.5 Multiple validations

[6]:
```
def test_validations(function,validations):
    for test in validations:
        result=function(**test['data'])
        if result== test['result']:
            print('Test Passed ->: {}'.format(test['description']))
        else:
            print('Test Failed ->: {}'.format(test['description']))

        print('\t Input   ->: Input {}'.format(test['data']))
        print('\t Results ->: Output {}, expected {}'.
 ↪format(result,test['result']))
```

[7]:
```
validations= []
```

[8]:
```
validations.append({
    'data':{
        'numbers': [1,3,7,13,21,45,67,89],
        'search': 1
    },
    'result' : 0,
    'description':'Number at the beginning'
})
```

[9]:
```
validations.append({
    'data':{
        'numbers': [1,3,7,13,21,45,67,89],
        'search': 89
    },
    'result' : 7,
    'description':'Number at the end'

})
```

[10]:
```
validations.append({
    'data':{
        'numbers': [1,3,7,13,21,45,67,89],
        'search': 100
    },
    'result' : -1,
    'description':'Missing number'
})
```

[11]:
```
validations.append({
    'data':{
        'numbers': [89],
        'search': 89
    },
    'result' : 0,
    'description':'One number only'
})
```

[12]:
```
validations.append({
    'data':{
        'numbers': [1,3,3,4,7,13,21,45,67,89],
        'search': 7
    },
    'result' : 4,
    'description':'Number Repetions'

})
```

[13]:
```
test_validations(find_number_linear,validations)
```

```
Test Passed ->: Number at the beginning
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
1}
        Results ->: Output 0, expected 0
Test Passed ->: Number at the end
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
89}
        Results ->: Output 7, expected 7
Test Passed ->: Missing number
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
100}
        Results ->: Output -1, expected -1
Test Passed ->: One number only
        Input   ->: Input {'numbers': [89], 'search': 89}
        Results ->: Output 0, expected 0
Test Passed ->: Number Repetions
        Input   ->: Input {'numbers': [1, 3, 3, 4, 7, 13, 21, 45, 67, 89],
'search': 7}
        Results ->: Output 4, expected 4
```

[14]:
```
validations.append({
    'data':{
        'numbers': [],
        'search': 1
    },
    'result' : -1,
    'description':'Empty'

})
```

[15]:
```
test_validations(find_number_linear,validations)
```

```
Test Passed ->: Number at the beginning
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
1}
        Results ->: Output 0, expected 0
Test Passed ->: Number at the end
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
89}
        Results ->: Output 7, expected 7
Test Passed ->: Missing number
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
100}
        Results ->: Output -1, expected -1
Test Passed ->: One number only
        Input   ->: Input {'numbers': [89], 'search': 89}
```

```
        Results ->: Output 0, expected 0
Test Passed ->: Number Repetions
        Input   ->: Input {'numbers': [1, 3, 3, 4, 7, 13, 21, 45, 67, 89],
'search': 7}
        Results ->: Output 4, expected 4
Test Passed ->: Empty
        Input   ->: Input {'numbers': [], 'search': 1}
        Results ->: Output -1, expected -1
```

[16]:
```
large_validation = {
    'data': {
        'numbers': [i for i in range(10000000)],
        'search': 99999999
    },
    'result': 99999999,
    'description':'Very large list'
}

len(large_validation['data']['numbers'])
```

[16]: 10000000

[17]:
```
%%time
find_number_linear(**large_validation['data'])
```

```
CPU times: user 304 ms, sys: 0 ns, total: 304 ms
Wall time: 303 ms
```

[17]: -1

2.2 Complexity

The complexity of a algoritm is based on the amount of time or space it take to complete the process for a input of size N.

For the previous search function the time complexity is O(N) where N is the size of the array passed to the function and O(1) for space complexity.

2.3 Best Solution

3 Steps

1. Find the number in the middle.
2. If it matches then you are done.
3. If the number is lower than the search look in the left side of the array.
4. If the number is higher than the serach look in the rigth side of the array.
5. If there are no more numbers return -1

[18]:
```python
def find_number_binary(numbers, search):
    rigth= 0
    left= len(numbers)-1

    while rigth <= left:
        center = (rigth + left) // 2
        center_number = numbers[center]

        if center_number == search:
            return center
        elif center_number < search:
            rigth = center + 1
        elif center_number > search:
            left = center - 1

    return -1
```

[19]:
```python
test_validations(find_number_binary,validations)
```

```
Test Passed ->: Number at the beginning
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
1}
        Results ->: Output 0, expected 0
Test Passed ->: Number at the end
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
89}
        Results ->: Output 7, expected 7
Test Passed ->: Missing number
        Input   ->: Input {'numbers': [1, 3, 7, 13, 21, 45, 67, 89], 'search':
100}
        Results ->: Output -1, expected -1
Test Passed ->: One number only
        Input   ->: Input {'numbers': [89], 'search': 89}
        Results ->: Output 0, expected 0
Test Passed ->: Number Repetions
        Input   ->: Input {'numbers': [1, 3, 3, 4, 7, 13, 21, 45, 67, 89],
'search': 7}
        Results ->: Output 4, expected 4
Test Passed ->: Empty
        Input   ->: Input {'numbers': [], 'search': 1}
        Results ->: Output -1, expected -1
```

[20]:
```python
%%time
find_number_binary(**large_validation['data'])
```

```
CPU times: user 9 µs, sys: 0 ns, total: 9 µs
Wall time: 9.78 µs
```

[20]: -1

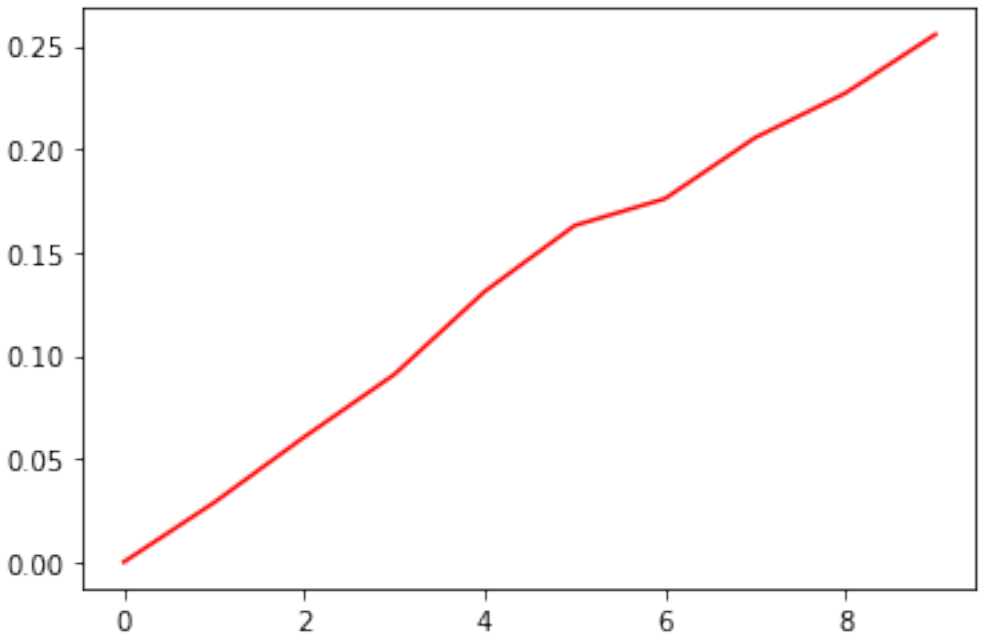
[21]:
```
import time
def get_time(function,validation):
    start = time.time()
    function(**validation['data'])
    end = time.time()
    return(end - start)

def simulation(function,validation):
    sim_number=10000000
    step=1000000
    results=[]
    for i in range(0,10):
        validation['data']['search']=i*step
        validation['result']=i*step
        results.append(get_time(function,validation))

    return results
```

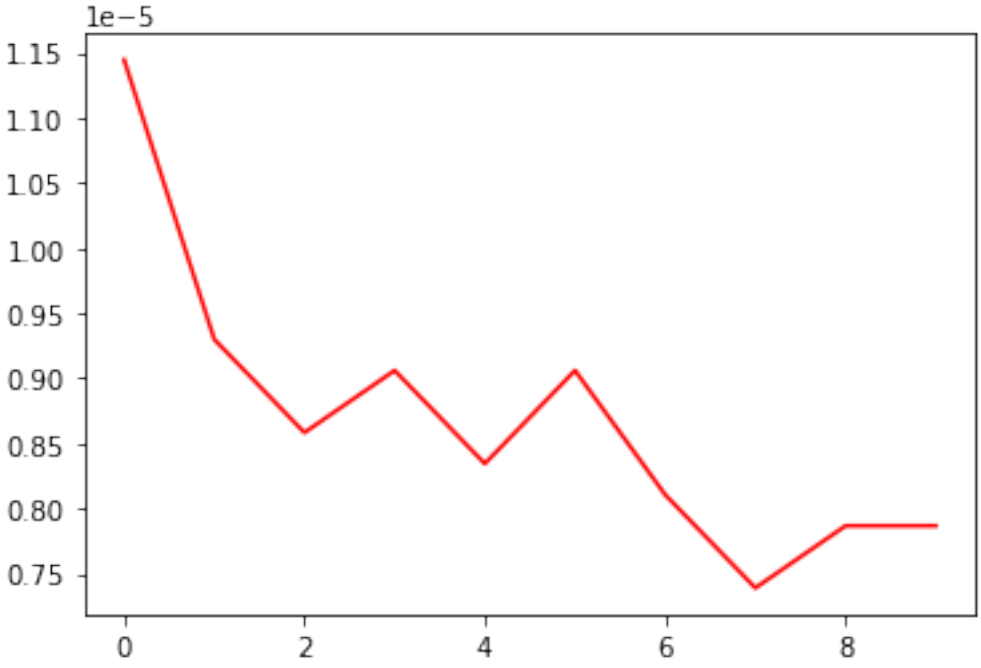
[22]:
```
import matplotlib.pyplot as plt
import numpy as np

ypoints=simulation(find_number_linear,large_validation)
plt.plot(ypoints,color='r')
plt.show()
```



[23]:
```
import matplotlib.pyplot as plt
import numpy as np

ypoints=simulation(find_number_binary,large_validation)
plt.plot(ypoints, color = 'r')
plt.show()
```



3.1 Building environment

```
cd ~/.virtualenvs
python3 -m venv ads
. ~/.virtualenvs/ads/bin/activate
python3 -m pip install jupyterlab
python3 -m pip install numpy
python3 -m pip install matplotlib

mkdir ~/ads
cd ~/ads
```

3.2 Execute Jupyter Lab

```
. ~/.virtualenvs/ads/bin/activate
cd ~/ads
jupyter lab
```