Sharif University of Technology
Department of Computer Engineering

Fundamentals of Programming

Python Language

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Combination of Loops and Conditional Logic (Cont.)

Exercise 9: Arbitrary Base Conversion from 2 to 16

- Write a function that takes a string representing a number in base 2 through 16 and converts it to its equivalent in base 10.
- The function should be able to handle bases up to 16.
- The function should return -1 if the string is not a valid number in the given base.

Solution to Exercise 9: Arbitrary Base Conversion from 2 to 16

```
def base_conversion(s, b):
    """Return the base 10 representation of s in base b.
    """
    result = 0
    for i, digit in enumerate(s[::-1]):
        if digit.isdigit():
            value = int(digit)
        else:
            value = ord(digit) - ord('A') + 10
        if value >= b:
            return -1
        result += value * b ** i
    return result
```

Solution to Exercise 9: Arbitrary Base Conversion from 2 to 16

Tracing the code for `base_conversion('101', 2)` gives:

```
i = 0, digit = '1', value = 1, result = 1
i = 1, digit = '0', value = 0, result = 1
i = 2, digit = '1', value = 1, result = 5
```

Exercise 10: Reduce a Fraction to Lowest Terms

- Write a function that takes a fraction as a string and returns the fraction reduced to lowest terms.

- The function should return -1 if the string is not a valid fraction.

Solution to Exercise 10: Reduce a Fraction to Lowest Terms

```
def gcd(a, b):
    """Return the greatest common divisor of a and b.
    """
    while b != 0:
        a, b = b, a % b
    return a

def reduce_fraction(fraction):
    """Return the fraction reduced to lowest terms.
    """
    numerator, denominator = fraction.split('/')
    numerator, denominator = int(numerator), int(denominator)
    divisor = gcd(numerator, denominator)
    return str(numerator // divisor) + '/' + str(denominator // divisor)
```

Exercise 11: Sieve of Eratosthenes

- The sieve of Eratosthenes is one of the most efficient ways to find all primes smaller than n when n is smaller than 10 million or so.
- The idea is to start with a list of all numbers up to n and repeatedly remove multiples of primes from the list.
- The running time of this algorithm is $\mathcal{O}(n \log \log n)$.

Code for Exercise 11: Sieve of Eratosthenes

```
def sieve(n):
    """Return a list of all primes less than n.
    """
    primes = [True] * n
    primes[0] = primes[1] = False
    for i in range(2, n):
        if primes[i]:
            for j in range(i*i, n, i):
                primes[j] = False
    return [i for i, prime in enumerate(primes) if prime]
```

Useful Stuff

Zip in Python

- The `zip()` function takes iterables (can be zero or more), aggregates them in a tuple, and return it.
- The `zip()` function returns an iterator of tuples based on the iterable objects.
- If we do not pass any parameter, zip() returns an empty iterator.

Zip in Python

```
# Python code to demonstrate the working of
# zip()

# initializing lists
name = [ "Manjeet", "Nikhil", "Shambhavi", "Astha" ]
roll_no = [ 4, 1, 3, 2 ]

# using zip() to map values
mapped = zip(name, roll_no)

# converting values to print as set
mapped = set(mapped)

# printing resultant values
print ("The zipped result is : ",end="")
print (mapped) # prints {('Manjeet', 4), ('Nikhil', 1), ('Astha', 2), ('
                                        Shambhavi', 3)}
```

Zip in Python

```
# unzipping values
namez, roll_noz = zip(*mapped)

print ("The unzipped result: \n",end="")

# printing initial lists
print ("The name list is : ",end="")
print (namez) # prints ('Manjeet', 'Nikhil', 'Shambhavi', 'Astha')

print ("The roll_no list is : ",end="")
print (roll_noz) # prints (4, 1, 3, 2)
```

Dynamic Programming: Fibonacci

- Dynamic programming is a method for solving a complex problem by breaking it down into a collection of simpler subproblems, solving each of those subproblems just once, and storing their solutions.

- The next time the same subproblem occurs, instead of recomputing its solution, one simply looks up the previously computed solution, thereby saving computation time.

Previous Example: Fibonacci

```
def fib(n):
    """Return the nth Fibonacci number.
    """
    if n == 0:
        return 0
    elif n == 1:
        return 1
    else:
        return fib(n-1) + fib(n-2)
```

Dynamic Programming: Fibonacci

```
def fib_memo(n, memo):
    """Return the nth Fibonacci number.
    """
    if n in memo:
        return memo[n]
    elif n == 0:
        result = 0
    elif n == 1:
        result = 1
    else:
        result = fib_memo(n-1, memo) + fib_memo(n-2, memo)
    memo[n] = result
    return result
```

Time Magic in Jupyter Notebook

```
%timeit fib(20)
```

```
%timeit fib_memo(20, {})
```

%%time Magic in Jupyter Notebook

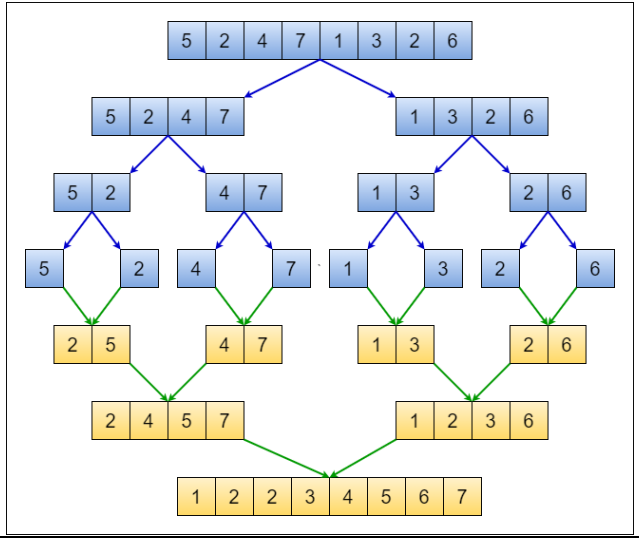
```
%%time
fib(20)
```

```
%%time
fib_memo(20, {})
```

Merge Sort

- Merge sort is a sorting technique based on divide and conquer technique.
- With worst-case time complexity being $\mathcal{O}(n \log n)$, it is one of the most respected algorithms.
- Merge sort first divides the array into equal halves and then combines them in a sorted manner.

Merge Sort


5 2 4 7 1 3 2 6
5 2 4 7
1 3 2 6
5 2
4 7
1 3
2 6
5
2
4
7
1
3
2
6
2 5
4 7
1 3
2 6
2 4 5 7
1 2 3 6
1 2 2 3 4 5 6 7

Merge Sort

```
def merge_sort(arr):
    """Return a sorted copy of arr.
    """
    if len(arr) <= 1:
        return arr
    mid = len(arr) // 2
    left = merge_sort(arr[:mid])
    right = merge_sort(arr[mid:])
    return merge(left, right)
```

Merge Sort

```
    def merge(left, right):
        """Return a sorted list of left and right.
        """
        result = []
        i, j = 0, 0
        while i < len(left) and j < len(right):
            if left[i] <= right[j]:
                result.append(left[i])
                i += 1
            else:
                result.append(right[j])
                j += 1
        result += left[i:]
        result += right[j:]
        return result
```

Using the Random Shuffle in Python

- The `random` module provides access to functions that support many operations.
- Perhaps the most important thing is that it allows you to generate random numbers.
- The `random` module contains a function called `shuffle` that takes a list and re-arranges the order of the elements.

```
import random
arr = [1, 2, 3, 4, 5]
random.shuffle(arr)
print(arr) # prints [3, 2, 5, 1, 4]
```

References

References I

[1] B Downey, A. (2015). Think Python: How to Think Like a Computer Scientist-2nd Edition.

[2] Deitel, H. M., & Deitel, P. J. (2004). C: How to program. Pearson Educacion.

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