National University of Singapore School of Computing CS1010X: Programming Methodology Semester II, 2024/2025

Tutorial 10 Memoization & Dynamic Programming

Dynamic Programming and Memoization

1. Consider the following function:

$$f(n) = \begin{cases} n/2 & \text{if } even(n) \\ 3n+1 & \text{if } odd(n) \end{cases}$$

The Collatz conjecture states that for any integer n, the sequence n, f(n), f(f(n)), \cdots will eventually reach 1.

We define the Collatz distance for an integer n as the number of steps needed to reach 1.

(a) Write a function collatz_distance(n).

```
>>> collatz_distance(1)
0
>>> collatz_distance(4)
2
>>> collatz_distance(27)
111
```

(b) Write a function $max_collatz_distance(n)$, which computes the maximum Collatz distance of 1, 2, 3, ..., n.

```
>>> max_collatz_distance(6)
8
>>> max_collatz_distance(8)
16
>>> max_collatz_distance(18)
20
```

- (c) Give a memoized version of max_collatz_distance_memo(n) using memoize as provided in the lecture.
- (d) Memoize it without using the function provided in the lecture. You should be able to do better.

Exception Handling

2. The following function accesses a URL on the internet and retrieves its contents:

```
from urllib.request import urlopen
from urllib.parse import urlsplit
from urllib.error import *
def httpget(url):
    parsed = urlsplit(url)
    if not parsed.scheme: #protocol insertion
        url = 'http://' + url
    elif parsed.scheme != 'http':
        raise ValueError("Unknown protocol")
    return urlopen(url).read()
```

- (a) Your ability to access a URL on the internet is not guaranteed it is only on a "best effort" basis. An example of an URL is http://www.nus.edu.sg/. Describe qualitatively (no need for exact exceptions/error codes) some of the things that could go wrong.
- (b) Why is it a good idea to raise an error instead of simply returning a string 'Not Found' or an empty string to indicate that the URL is not accessible?
- (c) Suppose we are interested in 3 types of errors: user errors, internet errors and all other errors. A user error might be a mistyped URL while a internet error may be a connection problem.

For user errors, we try to catch URLError and $rethrow^1$ it as ValueError. For internet error, we try to catch HTTPError and rethrow it as custom error type InternetFail. For other errors, just rethrow.

Modify httpget to accomodate the above error handling.

Note: HTTPError is a subclass of URLError, hence the order is important. We want to handle the more specific error first.

¹When we catch an exception and raise it again, we are *rethrowing* that error.

(d) Using the above, write a function download_URLs(URL_filenames) to download a set of files, where URL_filenames is a list of pairs in the following format: [[URL1, filename1], [URL2, filename2], ...]. In this instance, the contents of URL1 should be saved locally as filename1.

Naturally, many errors can occur during downloading - if we get InternetFail or ValueError, we want to ignore those and continue downloading the rest of the list. Otherwise, we rethrow the error.

Hint: To save data to a file, use the following:
with open(filename, 'wb') as myFile:
 myFile.write(contents)