Computational Structures in Data Science

Lists & Higher Order Functions
Learning Objectives

• Learn three new common Higher Order Functions:
  – map, filter, reduce
• These each apply a function to a sequence (list) of data
• They are “lazy” so we may need to call list()

• Map: Transform each item
  – Input: A function and a sequence
  – Output: A sequence of the same length. The items may be different.
list(map(function_to_apply, list_of_inputs))

Transform each of items by a function.

e.g. square()

Inputs (Domain):
  • Function
  • Sequence

Output (Range):
  • A sequence

def map(function, sequence):
    return [ function(item) for item in sequence ]

list(map(square, range(10)))
Lists & Higher Order Functions: Filter
Learning Objectives

• Learn three new common Higher Order Functions:
  – map, filter, reduce

• These each apply a function to a sequence (list) of data

• map/filter are “lazy” so we may need to call list()

• Filter: Keeps items matching a condition.
  – Input: A function and sequence
  – Output: A sequence, possibly with items removed. The items don’t change.
list(filter(function, list_of_inputs))

*Keeps* each of item where the function is true.

Inputs (Domain):
- Function
- Sequence

Output (Range):
- A sequence

```python
def filter(function, sequence):
    return [item for item in sequence if function(item)]
```
Lists & Higher Order Functions
Reduce
Learning Objectives

• Learn three new common Higher Order Functions:
  – map, filter, reduce

• These each apply a function to a sequence (list) of data

• Reduce: “Combines” items together, probably doesn’t return a list.
  – Input: A 2 item function and a sequence
  – A single value
reduce(function, list_of_inputs)

Successively **combine** items of our sequence
• function: add(), takes 2 inputs gives us 1 value.

Inputs (Domain):
• Function, with 2 inputs
• Sequence

Output (Range):
• An item, the type is the output of our function.

**Note:** We must import reduce from `functools`!

```python
def reduce(function, sequence):
    result = function(sequence[0], sequence[1])
    for index in range(2, len(sequence)):
        result = function(result, sequence[index])
    return result
```
Lists & Higher Order Functions

Acronym
Today’s Task: Acronym

Input: "The University of California at Berkeley"

Output: "UCB"

def acronym(sentence):
    """YOUR CODE HERE"""
Three super important HOFS

* For the built-in `filter/map`, you need to then call `list` on it to get a list. If we define our own, we do not need to call `list`.

`list(map(function_to_apply, list_of_inputs))`

Applies function to each element of the list

`list(filter(condition, list_of_inputs))`

Returns a list of elements for which the condition is true

`reduce(function, list_of_inputs)`

Applies the function, combining items of the list into a "single" value.
Bonus / Review

- Left over slides we didn’t get to.
What does this do?

```
list(map(capitalize,
    ['michael', 'Alex', 'Srinath', 'julia'])
))
```

Assume `capitalize('michael') == 'Michael'

A) ['michael', 'Alex', 'Srinath', 'julia']
B) ['Michael', 'Alex', 'Srinath', 'Julia']
C) []
D) Error
E) I'm lost.
What does this do?

```python
list(filter(return_false, range(100)))
```

Assume `return_false(42) == False`

A) `range(0, 100)` # A standard range object
B) `[0, 1, 2, ... 96, 97, 98, 99]`
C) `[]`
D) Error
E) I'm lost.
Higher Order Functions

• Functions that operate on functions
• A function

```python
def odd(x):
    return x%2==1

odd(3)
True
```

• A function that takes a function arg

```python
def filter(fun, s):
    return [x for x in s if fun(x)]

filter(odd, [0,1,2,3,4,5,6,7])
[1, 3, 5, 7]
```

Why is this not 'odd'?
Higher Order Functions (cont)

- A function that returns (makes) a function

```python
def leq_maker(c):
    def leq(val):
        return val <= c
    return leq

>>> leq_maker(3)
<function leq_maker.<locals>.leq at 0x1019d8c80>

>>> leq_maker(3)(4)
False

>>> filter(leq_maker(3), [0,1,2,3,4,5,6,7])
[0, 1, 2, 3]
```