CS051A
INTRO TO COMPUTER SCIENCE WITH TOPICS IN AI

6: Sequences

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Labs
Lecture 6: Sequences

- Lists
- Sequences
- Tuples
A program that contains a set of functions for reading in scores and calculating various statistics on them.

```python
# scores-list.py

# A set of functions for reading in scores and calculating
# various statistics from the input scores.

def get_scores():
    """
    Reads user input of numerical scores as floats into a list
    and returns the list
    :return: None
    """
```
**scores-list.py** - What does it do?

- First, it prompts the user to enter a list of scores one at a time
  - Uses a while loop that keeps asking the user for a new score. What is the exit condition?
    - Checks to see if the line is empty: `while line != ""`

- Then, calculate various statistics based on what was entered. How are we calculating these statistics?
  - Average?
    - We could keep track of the sum and the total number of scores entered and divide them at the end.
  - Max (min)?
    - Keep track of the largest (smallest) score seen so far. Each time a new one is entered, see if it's larger (smaller). If so, update the largest (smallest).
  - Median?
    - The challenge with median is that we can't calculate it until we have all of the scores. We need to sort them and then find the middle score.
  - Why can't we do this using int/float variables?
    - We don't know how many scores are going to be entered. Even if we did, if we had 100 students in the class, we'd need 100 variables!
Lists

- **List**: a data structure.
  - **Data structure**: a way of storing and organizing data.

- Lists allow us to store multiple values using only a single variable to refer to them!

- Creating lists: provide elements separated by comma and enclosed in square brackets.

- Lists are a type and represent a value, just like float, int, bool and str. We can assign them to variables, print them, etc.

```python
>>> [7, 4, 3, 6, 1, 2]
[7, 4, 3, 6, 1, 2]
>>> 10
10
>>> [10]
[10]
>>> my_list = [7, 4, 3, 6, 1, 2]
>>> my_list
[7, 4, 3, 6, 1, 2]
>>> type(my_list)
<class 'list'>
```
Accessing Lists

- []: creates an empty list.

- We can access a particular value in the list by using the [] to "index" into the list.
  - Indexing starts at 0!

- Be careful of index out of range errors!
  - We can only index from 0... length-1.

- Negative indexing counts back from the end of the list.

>>> my_list = [7, 4, 3, 6, 1, 2]
>>> my_list[3]
6
>>> my_list[0]
7
>>> my_list[20]
Traceback (most recent call last):
  File "/Library/Frameworks/Python.framework/Versions/3.8/bin/python3.8", line 1, in <module>
    exec(code, self.locals)
  File "<input>", line 1, in <module>
IndexError: list index out of range
>>> my_list[-1]
2
>>> type(my_list[3])
<class 'int'>
A list is a contiguous set of spaces in memory. 

We can store anything in each of these spaces.

In general, it's a good idea to have lists be homogeneous, i.e. be of the same type.
Slicing

- Sometimes, we want more than just one item from the list (this is called slicing).

- We can specify a range in the square brackets, [], using the colon (:) 
  
  - `list[start:end]` will return a new list with the elements from `start` index through `end-1`.
  
  - `list[start:]` will return a new list with the elements from `start` to the end of the list.
  
  - `list[:end]` will return a new list with the elements from 0 through `end-1`.
  
  - `list[:]` will return a copy of the entire list.

```python
>>> list_of_numbers = [32, 4, -1, 15, -20]
>>> list_of_numbers[0:3]
[32, 4, -1]
>>> list_of_numbers[1:4]
[4, -1, 15]
>>> list_of_numbers[1:]
[4, -1, 15, -20]
>>> list_of_numbers[:2]
[32, 4]
>>> list_of_numbers[:]
[32, 4, -1, 15, -20]
>>> list_of_numbers[1:1]
[]
>>> list_of_numbers[-3:-1]
[-1, 15]
```
Looping over lists

- We can use the for loop to iterate over each item in the list.
- This is often called a "foreach" loop, i.e. for each item in the list, do an iteration of the loop.

```python
>>> list_of_numbers = [32, 4, -1, 15, -20]
>>> for value in list_of_numbers:
...     print(value)
...     ...
32
4
-1
15
-20
```
Practice time

- Write a function called `sum` that returns the sum of all the values in a list of numbers.

```python
>>> def sum(numbers):
    total = 0
    for val in numbers:
        total += val
    return total

>>> sum([13, -2, 47, 9, -5])
62
```
Calculating the average of a list - the inelegant way

```python
def inelegant_average(scores):
    
    Calculates the average of the values in list scores in an inelegant way
    :param scores: (list) a list of numbers that correspond to `scores`
    :return: (float) the average of the values in scores
    
    sum = 0.0
    count = 0

    for score in scores:
        sum += score
        count += 1

    return sum / count
```
Calculating the average of a list - the elegant way

```python
def average(scores):
    ""
    Calculates the average of the values in list scores in an elegant way
    :param scores: (list) a list of numbers that correspond to scores
    :return: (float) the average of the values in scores
    ""
    return sum(scores) / len(scores)
```
Built-in functions over lists

- Length of list
  - `len(list)`
- Max of list
  - `max(list)`
- Min of list
  - `min(list)`
- Sum of list
  - `sum(list)`

```python
>>> list_of_numbers = [32, 4, -1, 15, -20]
>>> len(list_of_numbers)
5
>>> max(list_of_numbers)
32
>>> min(list_of_numbers)
-20
>>> sum(list_of_numbers)
30
```
List methods

- Lists are objects therefore have methods.
  - **Object**: a software bundle that consists of properties and behavior. Behavior is controlled by **methods**.
  - We call a method of an object using the **dot operator**.

- Syntax: `myList.someMethod(argument)`
- [https://docs.python.org/3/tutorial/datastructures.html](https://docs.python.org/3/tutorial/datastructures.html)
- `help([])`
- `help(list)`
append

- Adds a value at the end of a list.

```
>>> list_of_numbers = [32, 4, -1, 15, -20]
>>> list_of_numbers.append(47)
>>> list_of_numbers
[32, 4, -1, 15, -20, 47]
```

- Notice that `append` does not return a new list, it just modifies the existing list!
pop

- Removes a value from the end of a list and returns it.

```python
>>> list_of_numbers.pop()
47
>>> list_of_numbers
[32, 4, -1, 15, -20]
```

- Notice that `pop` both modifies the list and returns the last value. If you want to use this value, you need to store it.

```python
>>> popped = list_of_numbers.pop()
>>> popped
-20
```

- `pop` also has another version where you can specify the index.

```python
>>> list_of_numbers
[32, 4, -1, 15]
>>> list_of_numbers.pop(1)
4
>>> list_of_numbers
[32, -1, 15]
```
insert

- Inserts a value at a specific index.

```python
>>> list_of_numbers
[32, -1, 15]
>>> list_of_numbers.insert(2, 100)
>>> list_of_numbers
[32, -1, 100, 15]
```

- Notice that `insert` does not return a new list but modifies the underlying one.
sort

- Sorts a list in ascending order.

```python
>>> list_of_numbers
[32, -1, 100, 15]
>>> list_of_numbers.sort()
>>> list_of_numbers
[-1, 15, 32, 100]
>>> list_of_strings
['this', 'is', 'a', 'list', 'of', 'strings']
>>> list_of_strings.sort()
>>> list_of_strings
['a', 'is', 'list', 'of', 'strings', 'this']
```

- Again, sort does not return a new list but modifies the underlying one.
There is a function called `get_scores`. It gets the scores and returns them as a list.

- starts with an empty list,
- uses `append` to add them on to the end of the list,
- returns the list when the loop finishes.

`median` function

- sorts the values
  - notice again that sort does NOT return a value, but sorts the list that it is called on.
- returns the middle entry
Lists are mutable

- We can change (or mutate) the values in a list.
- Notice that many of the methods that we call on lists change the list itself.
- We can mutate lists with methods, but we can also change particular indices.

```python
>>> list_of_numbers
[-1, 15, 32, 100]
>>> list_of_numbers[2]=100
>>> list_of_numbers
[-1, 15, 100, 100]
```
Lecture 6: Sequences

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Sequences

- Lists are part of a general category of data structures called **sequences**.
- Sequences represent a... sequence of things.
- **All** sequences support a number of shared behavior.
  - The ability to index using `[]`.
  - The ability to slice using `[:]`.
  - A number of built-in functions:
    - `len`, `max`, `min`.
  - The ability to iterate over them with a for loop.
- We've actually seen one other sequence. Strings!
Strings as sequences

- We can do all sorts of sequence-like things to strings!
- Strings, however, are immutable! We cannot mutate them.
What does the list-to-string function do?

Creates a list from a string:

- Takes as input a list. A list of almost any type, as long as we can call `str()` on.
- Concatenates all the items in the list into a single string.
- `result` starts out as the empty string.
- It iterates through each item in the list and concatenates them on to the `result`.
- Returns the entire `result` list minus the last element (which is " ").
Alternate way of iterating over lists

```python
>>> for letter in fruit:
...     print(letter)
...
banana

>>> for i in range(0, len(fruit)):
...     print(fruit[i])
...
banana
```
Practice time

- Write a function called `multiply_lists` that takes two lists of numbers and creates a new list with the values pairwise multiplied. E.g.,

```python
>>> list1 = [1, 2, 1, 2]
...
>>> list2 = [1, 2, 3, 4]
...
>>> multiply_lists(list1, list2)
...
[1, 4, 3, 8]
```

```python
def multiply_lists(list1, list2):
    """
    Creates a new list that is the result of the multiplication
    :param list1: (list) the first list of numbers
    :param list2: (list) the second list of numbers
    :return: (list) a list where each index corresponds in list1 and list2
    """
    result = []

    if len(list1) != len(list2):
        print("Error: lists are not of equal length!")
    else:
        for i in range(len(list1)):
            result.append(list1[i] * list2[i])

    return result
```
Lecture 6: Sequences

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Tuples

- **Tuple**: an immutable list. Type of sequence.

- Tuples can be created using parentheses (instead of []).

```python
>>> my_tuple = (1, 2, 3, 4)
>>> my_tuple
(1, 2, 3, 4)
>>> another_tuple = ("a", "b", "c", "d")
>>> another_tuple
('a', 'b', 'c', 'd')
```

- Notice that when they print out, they also show using parentheses.
Tuples as immutable sequences

```python
>>> my_tuple[0]
1
>>> my_tuple[3]
4
>>> for val in my_tuple:
...     print(val)
...
1
2
3
4
>>> my_tuple[1:3]
(2, 3)
>>> my_tuple[0] = 1
Traceback (most recent call last):
  File "/Library/Frameworks/Python.framework/Versions...
    exec(code, selflocals)
File "<input>", line 1, in <module>
```
Unpacking tuples

- If we know how many items are in a tuple, we can "unpack" it into individual variables.

```python
>>> my_tuple = (1, 2, 3)
>>> my_tuple
(1, 2, 3)
>>> (x, y, z) = my_tuple
>>> x
1
>>> y
2
>>> z
3

>>> (x, y, z) = (10, 11, 12)
>>> x
10
>>> y
11
>>> z
12
>>> x, y, z = "apple", "banana", "pineapple"
>>> x
'apple'
>>> y
'banana'
>>> z
'pineapple'
```
Tuples are useful for representing data with fixed entries.

Look at the print_movies function `movies.py`.

- It iterates over the list, just like any other list.
- `movie_pair` is a tuple (each entry in the list is a tuple). We unpack the tuple to get at the two values in the tuple.
  - We also could have written `movie_pair[0]` and `movie_pair[1]` (see `print_movies2`), though unpacking is much cleaner.
- Once we have the two values, we can print them out
  - `\t` is a special character that represents a tab (like `\n`, which represents the end of line character)

Look at the `print_movies3` function.

- We can unpack the two values of the tuple *in* the for loop. Any of the variants is fine for this class!
get_movie_score function

- What does the get_movie_score function do?
  - Takes two parameters, a movie database and a movie title.
  - It iterates through the movie database and tries to find the matching title.
    - If it finds it, it returns the score.
    - If it doesn't find it, it will iterate through all of the movie entries, finish the for loop and return -1.0
Practice time

- Write a function called `my_max` that takes a list of positive numbers and returns the largest one.

```python
>>> def my_max(numbers):
...     max = -1
...     for num in numbers:
...         if num > max:
...             max = num
...     return max
```

- Key idea: have a variable that keeps track of the largest number seen so far. At each iteration, compare the current number to max, if it's bigger, update the max value.

- Why initialize it to -1? We need to initialize it to something that is smaller than any of the values. We could also have done something like `max = numbers[0]` (assuming that the input would have at least one value).
get_highestRatedMovie function

- What does the get_highestRatedMovie function do?
  - Very similar idea to my_max function.
    - We’re finding the largest score.
    - We also keep track of the movie with the highest score so that we can return that at the end.
Practice time

- Write a function called `get_movies_above_threshold` that takes as input a movie database and a critic score threshold and returns all of the movies above that threshold.

```python
def get_movies_above_threshold(movie_db, threshold):
    
    Given a database and a threshold critic score, it:
    :param movie_db: (list) a list of tuples that contain:
    :param threshold: (num) the threshold critic score:
    :return: (list) a list of movie titles that have:
    
    movies_above = []

    for (movie, score) in movie_db:
        if score >= threshold:
            movies_above.append(movie)

    return movies_above
```
Resources

- Textbook: Chapters 9 and 10
- `scores-list.py`
- `more-lists.py`
- `movies.py`

Practice Problems

- Practice 4 (solution)

Homework

- Assignment 3