Computational Structures in Data Science

Lecture 4:
Sequences and `for` Loops

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Announcements

Concurrent Enrollment / BGA Students:

-Working on expanding the class, should happen next week

- First ~15 who applied + accept will be admitted.

-Everyone else: Expanding the class by ~20 seats.

If you need access use the join link for Ed:

https://edstem.org/us/join/QMbsfr

Announcements

- https://go.c88c.org/4 -- Self Check
- https://go.c88c.org/qa4 -- Ed Thread

Please minimize talking and distractions.

- Sit off to the sides if you aren't using your devices for classs.

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Iteration with `while` Loops

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Learning Objectives

- Use a while loop to repeat some task.
- Write an expression to control when a while loop stops executing

while Statement – Iteration Control

- Repeat a block of statements until a *predicate expression* is not satisfied
- At the "end" of the body, we re-evaluate the expression, and continue as long as it True
- Like conditionals and functions, we indent the body one level

```
<initialization statements>
while <predicate expression>:
    <body statements>

<rest of the program>
```

Sum The Numbers

- This is a task we'll see many times!
- The sum of 1 to 10 (inclusive) is 55. A useless, but useful, fact.

```
total = 0
n = 1
while n <= 10:
    total += n
    n += 1
print(total)
```

While Loops and Text

- Index is the name used to track a position in some sequence.
- We can "index into" a string to get an individual letter
- `text[0] == "H"`

```
text = "Hello, C88C!"
index = 0
while index < len(text):
    print(text[index])
    index += 1 # Same as index = index += 1
```

Sum The Numbers As a Function

```
def sum_to_n(n):
    """
    >>> sum_to_n(10)
    55
    """
    total = 0
    i = 1
    while i <= n:
        total += i
        i += 1
    return total
```

Sum The Numbers As a Function

```
def sum_to_n_down(n):
    """
    >>> sum_to_n_down(10)
    55
    """
    total = 0
    while n > 0:
        total += n
        n -= 1
    return total
```

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`for` Loops

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Learning Objectives: Using Lists in Practice

- `for` Loops are a "generic" way to iterate over data.
- Compare a `for` loop and a `while` loop.
- Learn to use `range()`
- Use a string as a sequence of letters

REVIEW: while statement – iteration control

- Repeat a block of statements until a predicate expression is satisfied

```
<initialization statements>
while <predicate expression>:
    <body statements>

<rest of the program>


# Equivalent to a for loop:
text = "Hello, C88C!"
index = 0
while index < len(text):
    letter = text[index]
    print(letter)
    index += 1
```

`for` Statement – Iteration Control

- Repeat a block of statements for a structured sequence of variable bindings

```
<initialization statements>
for <variables> in <sequence expression>:
  <body statements>

<rest of the program>
```

Live Coding Demo

```
text = "Hello, C88C!"
index = 0
while index < len(text):
    letter = text[index]
    print(letter)
    index += 1

for letter in text:
    print(letter)
```

Live Coding Demo

```
index = 0
while index < 10:
    print(index)
    index += 1

for index in range(0, 10):
    print(index)
```

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Iteration with `for` Loops

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Learning Objectives: Using Lists in Practice

- `for` Loops are a "generic" way to iterate over data.
- Compare a `for` loop and a `while` loop.
- Learn to use `range()`
- Use a string as a sequence of letters

REVIEW: while statement – iteration control

- Repeat a block of statements until a predicate expression is satisfied

```
<initialization statements>
while <predicate expression>:
    <body statements>

<rest of the program>
```

```
text = "Hello, C88C!"
index = 0
while index < len(text):
    letter = text[index]
    print(letter)
    index += 1
```


`for` Statement – Iteration Control

Repeat a block of statements for a structured sequence of variable bindings

```
<initialization statements>
for <variables> in <sequence expression>:
  <body statements>

<rest of the program>
```

<sequence expression> — What's that?

- Common sequences:
  - `range()` – give me all the numbers
  - Strings, e.g, "Hello, C88C!"
    - What is it a sequence of? Characters!
  - lists (next!)
- We'll start with two basic facts:
  - `range(10)` is the numbers 0 to 9, or range(0, 10)
  - for loops (transparently) iterate 1 item at time

Comparing Loops

```
text = "Hello, C88C!"
index = 0
while index < len(text):
    letter = text[index]
    print(letter)
    index += 1

for letter in text:
    print(letter)
```

Live Coding Demo

```
index = 0
while index < 10:
    print(index)
    index += 1

for index in range(0, 10):
    print(index)
```

Summing 1 to N (Again)

```
def sum_to_n(n):
    total = 0
    for num in range(0, n + 1):
        total += num
    return total

def sum_to_n_down(n):
    total = 0
    for num in range(n, 0, -1):
        total += num
    return total
```

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Sequences

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Sequences [Docs]

- The term sequence refers generally to a data structure consisting of an indexed collection of values, which we'll generally call elements.
  - That is, there is a first, second, third value (which CS types call #0, #1, #2, etc.)
- A sequence may be finite (with a length) or infinite.
- It may be mutable (elements can change) or immutable.
- It may be indexable: its elements may be accessed via selection by their indices.
- It may be iterable: its values may be accessed sequentially from first to last.

<sequence expression> — What's that?

- Common sequences:
  - range() – give me all the numbers
  - Strings, e.g, "Hello, C88C!"
    - What is it a sequence of? Characters!
  - lists (next!)
- We'll start with two basic facts:
  - `range(10)` is the numbers 0 to 9, or range(0, 10)
  - `[]` means "indexing" an item in a sequence.
  - `"Hello"[0] == "H"`

Common Sequences

- *There are many types of sequences* in Python.
  - `range`
  - `string` (text data)
  - `list`
  - `tuple`
- Sequences all share some common properties.

`range`

- `range()` is a built in Python tool that generates a sequence of numbers.
  - It does not return a list unless we explicitly ask for one.
- It has many options: start, stop, and step.
- Range is *lazy!* It can be iterated over, but doesn't compute all its values at once.
  - We'll revisit this later.
- **GOTCHA:** Range is exclusive in the last value!
  - **`range(10)` is a sequence on 10 numbers from 0 to 9.**

Sequence Operations

Operation	Result
`x in s`	True if an item of ***s*** is equal to ***x***, else False
`x not in s`	False if an item of ***s*** is equal to ***x***, else True
`s + t`	the concatenation of ***s*** and ***t***
`s * n or n * s`	equivalent to adding ***s*** to itself ***n*** times
`s[i]`	***i***th item of ***s***, origin 0
`s[i:j]`	slice of ***s*** from ***i*** to ***j***
`s[i:j:k]`	slice of ***s*** from ***i*** to ***j*** with step ***k***
`len(s)`	length of ***s***
`min(s)`	smallest item of ***s***
`max(s)`	largest item of ***s***
`s.index(x[, i[, j]])`	index of the first occurrence of ***x*** in ***s*** (at or after index ***i*** and before index ***j***)
`s.count(x)`	total number of occurrences of ***x*** in ***s***

Live Coding Demo

```
sum(range(0, 11))

def sum_to_n(n):
    return sum(range(0, n + 1))

text = 'Hello, C88C!'
len(text)
text.count('l')
text.count(8)
text.count('8')
```

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Lists

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Learning Objectives

- Lists are a new data type in Python.
- Lists can store any kind of data and be any length.
- We start counting items of lists at 0.
- Lists are *mutable*. We can change their data!

Lists

- A structure in Python that can hold many elements
  - Also referred to an an “array” in other programming languages.
- Lists are used to group similar items together.
  - A “contact list”, a “list of courses”, a “to do list”
- Python lists are *really* flexible!
  - Can contain any type of data
  - Can mix and match types!
  - Can add and delete items

Types We've Learned So Far

- Each *type* of data has a specific set of functions (methods) you can apply to them, and certain properties you can access.
- `int` / Integers
  - `1, -1, 0`, …
- `float` ("decimal numbers")
  - `1.0, 3.14159, 20.0`
- `string`
  - `"Hello, CS88"`
- `function`
  - `max(), min(), print(), your own functions!`
- **`list`**
  - **`['CS88', 'DATA8', 'POLSCI2', 'PHILR1B']`**

List Operations [Python Docs!]

- `[]` "square brackets": Used to access items in a list. We start at 0!
- len(): The number of items in a list
- +: We can add lists together
- min(), max(): Functions that take in a list and return some info.
- Converting between types: Strings and Lists:
  - `<string>.split(<separator>)` → List of strings
    - `'I am taking CS88.'.split(' ')`
  - `<string>.join(<list>)` → String, with the items of a list joined together.
    - `' '.join(['I', 'am', 'taking', 'C88C.'])`
- Lots more interesting tools!

Selecting Elements From a List (A Reference, Don't Memorize Yet!)

- **Selection** refers to extracting elements by their index.
- **Slicing** refers to extracting subsequences.
- These work uniformly across sequence types.

```
L = [2,0,9,10,11]
S  =  "Hello, world!"
L[2]== 9
L[-1] == L[len(t)-1] == 11
S[1] == "e" # Each element of a string is a one-element string.
L[1:4] == (L[1], L[2], L[3]) == (0, 9, 10)
S[1:2] == S[1] == "e"
S[0:5] == "Hello", S[0:5:2] == "Hlo", S[4::-1] == "olleH"
```

Rules of Indexing & Slicing

- We start counting from 0.
  - You *will* mess this up. We all do. It's ok.
  - There's lots of bad dad jokes about this. ☺
- Python provides flexibility but can be confusing.
  - `[0]` means the first item
  - `[-1]` means the last item, [-2] 2nd to last, and so on
- **Slicing: The last value is *exclusive!***
  - `[:stop], e.g. my_list[:5] # items 0-4`
  - `[start:stop], e.g. my_list[2:5] # items 2,3,4`
  - `[start:stop:step] e.g. my_list[0:8:2] # items 0,2,4,6`

Sequence Operations (Review and Reference)

Operation	Result
`x in s`	True if an item of ***s*** is equal to ***x***, else False
`x not in s`	False if an item of ***s*** is equal to ***x***, else True
`s + t`	the concatenation of ***s*** and ***t***
`s * n or n * s`	equivalent to adding ***s*** to itself ***n*** times
`s[i]`	***i***th item of ***s***, origin 0
`s[i:j]`	slice of ***s*** from ***i*** to ***j***
`s[i:j:k]`	slice of ***s*** from ***i*** to ***j*** with step ***k***
`len(s)`	length of ***s***
`min(s)`	smallest item of ***s***
`max(s)`	largest item of ***s***
`s.index(x[, i[, j]])`	index of the first occurrence of ***x*** in ***s*** (at or after index ***i*** and before index ***j***)
`s.count(x)`	total number of occurrences of ***x*** in ***s***

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Demo

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List Comprehensions

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Learning Objectives

- List comprehensions let us build lists "inline".
- List comprehensions are an *expression that returns a list.*
- We can easily “filter” the list using a conditional expression, i.e. `if`

Data-driven iteration

- describe an expression to perform on each item in a sequence
- let the data dictate the control
- In some ways, nothing more than a concise for loop.

```
[ <expr with loop var> for <loop var> in <sequence expr > ]
```

```
[ <expr with loop var> for <loop var> in <sequence expr >
if <conditional expression with loop var> ]
```