12. Loops and Logic

Topics:
- Loop-Body Return
- The Idea of a Random Walk
- Showcase: Open-Ended Iteration
- Showcase: Computing Averages
- Showcase: Top-Down Development

Loop-Body Returns

Another way to terminate a loop.

Uses the fact that in a function, control is passed back to the calling program as soon as a return statement is encountered.

A Problem

Write a function

```python
def MyFind(char, s):
    k = 0
    while k < len(s) and char != s[k]:
        k += 1
    if k == len(s):
        return False
    else:
        return True
```

Typical While-Loop Solution

```python
def MyFind(char, s):
    k = 0
    while k < len(s) and char != s[k]:
        k += 1
    if k == len(s):
        return False
    else:
        return True
```

While-Loop Solution with a Loop-Body Return

```python
def MyFind(char, s):
    k = 0
    while k < len(s):
        if s[k] == char:
            return True
        k += 1
    return False
```

The function "jumps out of the loop" and returns True should it encounter an instance of char. If the loop runs to completion, that means there is no instance of char.
For Loop Solution with a Loop Body

```python
def MyFind(char, s):
    for k in range(len(s)):
        if s[k] == char:
            return True
    return False
```

The function “jumps out of the loop” and returns True should it encounter an instance of char. If the loop runs to completion, that means there is no instance of char.

Another For Loop Solution with a Loop Body

```python
def MyFind(char, s):
    for c in s:
        if c == char:
            return True
    return False
```

The function “jumps out of the loop” and returns True should it encounter an instance of char. If the loop runs to completion, that means there is no instance of char.

The Random Walk Idea

-5 -4 -3 -2 -1 0 1 2 3 4 5

We have a “runway” made up of 1x1 tiles.

There are 2L+1 tiles. (L = 5 in the above.)

We call L the “length of the runway.”

The center tile is located at x = 0.

The Random Walk Idea

-5 -4 -3 -2 -1 0 1 2 3 4 5

Starting at the center tile, a robot hops from tile to tile according to a coin flip.

Heads: Hop right one tile.

Tails: Hop left one tile.

The simulation over when robot reaches either end (a.k.a. the boundary) of the runway.

Implement ShowRandomWalk.py

```python
from random import randint as randi

def RandomWalk(L):
    # Returns the number of hops for a single random walk.

def AveRandomWalk(L, n):
    # Simulate n length-L random walks and returns average number of required hops

if __name__ == '__main__':
    # Display the value of AveRandomWalk for various values of L
The Application Script

```python
if __name__ == '__main__':
    n = 1000  # Number of trials
    for L in range(5, 45, 5):
        print(L, AveRandomWalk(L, n))
```

Check out the cases \( L = 5, 10, 15, 20, 25, 30, 35, 40 \):

The Function \( \text{AveRandomWalk}(L,n) \)

```python
def AveRandomWalk(L, n):
    s = 0
    for k in range(0, n):
        RequiredHops = RandomWalk(L)
        s += RequiredHops
    ave = float(s)/float(n)
    return ave
```

The Function \( \text{RandomWalk}(L) \)

```python
def RandomWalk(L):
    hops = 0; x = 0
    while abs(x) < L:
        r = randi(0, 1)
        if r == 0:
            x = x + 1
        else:
            x = x - 1
        hops += 1
    return hops
```

Initializations. The robot starts at \( x = 0 \).

If the condition is True, the robot has not yet reached the boundary and we keep iterating.

We simulate the coin toss by picking 0 or 1 at random.
The While Loop

To more fully understand how this works, let’s look at the execution of this while loop:

```python
x = 0
while abs(x) < 5:
    r = randi(0,1)
    if r == 0:
        x = x+1
    else:
        x = x-1
```

Understanding the While Loop

Assume r = 0
Coin = Heads
Hop Right

The value of \( x \) is increased from 0 to 1.

Understanding the While Loop

Assume r = 1
Coin = Tails
Hop Left

abs(x) < 5 is true.
Robot not at boundary.
Loop continues.
Understanding the While Loop

\[ x = 0 \]
while abs(x) < 5:
    \[
    r = \text{randi}(0,1)
    \]
    if r == 0:
        x = x+1
    else:
        x = x-1

The value of x is decreased from 1 to 0.

Assume \( r = 0 \)
Coin = Heads
Hop Right

x = 0
while abs(x) < 5:
    \[
    r = \text{randi}(0,1)
    \]
    if r == 0:
        x = x+1
    else:
        x = x-1

abs(x) < 5 is true.
Robot not at boundary.
Loop continues

The value of X is increased from 0 to 1.

Assume \( r = 0 \)
Coin = Heads
Hop Right

x = 0
while abs(x) < 5:
    \[
    r = \text{randi}(0,1)
    \]
    if r == 0:
        x = x+1
    else:
        x = x-1

abs(x) < 5 is true.
Robot not at boundary.
Loop continues

x = 0
while abs(x) < 5:
    \[
    r = \text{randi}(0,1)
    \]
    if r == 0:
        x = x+1
    else:
        x = x-1

Assume \( r = 0 \)
Coin = Heads
Hop Right
Understanding the While Loop

\[ x = 0 \]
while \( \text{abs}(x) < 5 \):
   \[ r = \text{randi}(0,1) \]
   if \( r == 0 \):
      \[ x = x + 1 \]
   else:
      \[ x = x - 1 \]

abs(\( x \)) < 5 is true. Robot not at boundary. Loop continues.
x = 0
while abs(x) < 5:
    r = randi(0,1)
    if r == 0:
        x = x+1
    else:
        x = x-1

abs(x) < 5 is true.
Robot not at boundary.
Loop continues

Assume r = 0
Coin = Heads
Hop Right

x = 0
while abs(x) < 5:
    r = randi(0,1)
    if r == 0:
        x = x+1
    else:
        x = x-1

abs(x) < 5 is true.
Robot not at boundary.
Loop continues

x = 0
while abs(x) < 5:
    r = randi(0,1)
    if r == 0:
        x = x+1
    else:
        x = x-1

Assume r = 1
Coin = Heads
Hop Right

The value of X is increased from 2 to 3.
Understanding the While Loop

```python
x = 0
while abs(x) < 5:
    r = randi(0,1)
    if r == 0:
        x = x+1
    else:
        x = x-1
```

The value of X is increased from 3 to 4.

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Understanding the While Loop

```python
x = 0
while abs(x) < 5:
    r = randi(0,1)
    if r == 0:
        x = x+1
    else:
        x = x-1
```

abs(x) < 5 is true.
Robot not at boundary.
Loop continues

---

Understanding the While Loop

```python
x = 0
while abs(x) < 5:
    r = randi(0,1)
    if r == 0:
        x = x+1
    else:
        x = x-1
```

Assume r = 0
Coin = Heads
Hop Right

The value of X is increased from 4 to 5.

---

Understanding the While Loop

```python
x = 0
while abs(x) < 5:
    r = randi(0,1)
    if r == 0:
        x = x+1
    else:
        x = x-1
```

abs(x) < 5 is False.
Robot is on the boundary.
Loop TERMINATES

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Sample Output

<table>
<thead>
<tr>
<th>L</th>
<th>Ave</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>93</td>
</tr>
<tr>
<td>15</td>
<td>219</td>
</tr>
<tr>
<td>20</td>
<td>399</td>
</tr>
<tr>
<td>25</td>
<td>649</td>
</tr>
<tr>
<td>30</td>
<td>917</td>
</tr>
<tr>
<td>35</td>
<td>1259</td>
</tr>
<tr>
<td>40</td>
<td>1594</td>
</tr>
</tbody>
</table>

Averages based on 1000 trials.

Looks like doubling L increases the average by a factor of 4.

Insight through Computing!