Random Walks and Defining Functions

FEB 16TH

If we take a random walk, will we go places?

- **Problem:** Simulate a *random walk* in which a person starts of at point 0 and at each step randomly picks a direction (left or right) and moves 1 step in that direction.
- Take a positive integer n and terminate the simulation when the walk reaches n or –n.
- Report the *average* number of steps it took for the walk to terminate.
- Do this for various n and plot the results to get a sense of how rapidly the walk terminates, as a function of n.

The *random* module

- Programs for games and simulation use *randomization* extensively.

- In games, you want to add an element of randomness to the obstacles or adversaries.

- In simulations (e.g., traffic simulation) you want to introduce actors into your simulation according to certain probability distribution.

Some functions in the `random` module

- `random.randint(a, b)`: return a random integer *N* such that a <= N <= b.
- `random.random()`: Return the next random floating point number in the range [0.0, 1.0).
- `random.uniform(a, b)`: Return a random floating point number *N* such that a <= N <= b for a <= b and b <= N <= a for b < a.

Simple Example

Problem: Write a program that takes as input a positive integer *n* and simulates *n* rolls of two six-sided dice. The program should report the number of times 7 appears as the sum of the outcomes of the two dice rolls.

Solution

```
# Programmer: Sriram Pemmaraju
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# This program simulates the roll of two six-sided dice
# as many times as specified by the input. Then the program
# outputs the number of times 7 shows up as the sum of the two
# dice rolls

import random
n = int(raw_input("Enter the number of times you want the dice rolled: "))

counter = 0 # keeps track of the number of rolls
numSevens = 0 # keeps track of the number of sevens

while counter < n:
    sumRolls = random.randint(1, 6) + random.randint(1, 6)
    if sumRolls == 7:
        numSevens = numSevens + 1

    counter = counter + 1

print "The number of sevens is", numSevens
```

Taking a single random step

```
import random

# Version 1. This program starts off a person at 0 and moves
# her one step to the left or right, at random.

location = 0
step = random.randint(0, 1) # returns 0 or 1, each with prob. 1/2
if step == 0:
    step = -1
location = location + step
print location
```

Simulating the random walk

```
import random

# Version 2. This program starts off a person at 0 and moves
# her left or right, at random one step at a time until she reaches
# the "barrier" at n or - n.

n = input("Enter a positive integer: ")
location = 0

# Loop terminates when the location reaches n or -n
while abs(location) != n:
    step = random.randint(0, 1)  # returns 0 or 1, each with prob. 1/2
    if step == 0:
        step = -1
    location = location + step

print location
```

Counting the length of the random walk

```
import random

# Version 3. This program starts off a person at 0 and moves
# her left or right, at random one step at a time until she reaches
# the "barrier" at n or - n. It outputs the length of the walk.

n = input("Enter a positive integer: ")
location = 0 # tracks the location of the person
length = 0 # tracks the length of the random walk

# Loop terminates when the location reaches n or -n
while abs(location) != n:
    step = random.randint(0, 1) #returns 0 or 1, each with prob. 1/2
    if step == 0:
        step = -1
    location = location + step
    length = length + 1

print length
```

What more is there to do?

There are two more things we need to do to solve our problem:

1. Find the average length of a walk, for a particular value *n* of the barrier. We have to decide how many runs to take the average over.

2. Repeat this for various values of *n* and try to understand the trend.

We need a loop around our current code to do (1) and another loop around that code to do (2).

Defining a function

- Things have become complicated enough that we need to reorganize our code using functions.
- The plan is to define a function called `randomWalk` that takes *n* (the barrier distance) as an *argument* and *returns* the length of a simulated random walk.
- We can then just *call* this function from the main part of the program.

The function randomWalk

```
# This function takes the barrier distance n as an argument, simulates
# the random walk until it hits the barrier (n or -n), and returns the
# length of the random walk

def randomWalk( n ):
    location = 0 # tracks the location of the person
    length = 0 # tracks the length of the random walk

    # Loop terminates when the location reaches n or -n
    while abs(location) != n:
        step = random.randint(0, 1) #returns 0 or 1, each with prob. 1/2
        if step == 0:
            step = -1
        location = location + step
        length = length + 1

    return length
```

Notes about this function

- The first line of the function:

```
def randomWalk( n )
```

Python keyword

function name

argument list

- The body of the function is indented.
- It is as though `n` is input to the function.
- A function can have one or more arguments
- The last line of the function is usually a return:

```
return length
```

The rest of the program

```
n = input("Enter a positive integer: ")
print randomWalk(n)
```

- `randomWalk(n)` is a call to the function `randomWalk` providing it the number `n` that the user as input as an argument.
- In order to execute the print statement, the function call `randomWalk(n)` needs to be executed first.
- This means that "control" is transferred to the function and we start executing the function starting with its first line.
- The value that the function returns essentially replaces the function call.

Averaging over 100 simulations

```
n = input("Enter a positive integer: ")

count = 0 # tracks the number of times the walk is repeated
sum = 0 # sum of the lengths of the walk; needed for average
while count < 100:
    sum = sum + randomWalk(n)
    count = count + 1

print float(sum)/100
```

Making another function

```
# This function repeats a random walk with barrier n as many times
# as specified by the argument numRepititions and returns the length
# of the walk, averaged over all the repititions

def manyRandomWalks(n, numRepititions):
    count = 0 # tracks the number of times the walk is repeated
    sum = 0 # sum of the lengths of the walk; needed for average

    # Repeats the random walk as many times as specified by numRepititions
    while count < numRepitions:
        sum = sum + randomWalk(n)
        count = count + 1

    return float(sum)/100
```

The rest of the program

```
n = input("Enter a positive integer: ")
print manyRandomWalks(n, 100)
```

- The function call needs to supply arguments in the correct order, i.e., in the order specified in the function definition.
- Names in the function call have nothing to do with names in the function definition. We could have written

```
m = input("Enter a positive integer: ")
print manyRandomWalks(m, 100)
```

And the value of `m` and the value `100` would be used for `n` and `numRepititions` in the function.

Trying this out for different barrier values

```
m = 10 # tracks the value of the barrier
# m travels through 10, 20, ..., 100 in this loop and we compute and print the
# average walk length for each m
while m <= 100:
    print manyRandomWalks(m, 100)
    m = m + 10
```

Sample output

112.86
376.4
827.6
1628.04
2570.6
3594.2
4616.14
6035.6
8596.58
10948.58