19. Lists of Objects

Topics:

Example: The class Disk
Boolean-Valued Methods
A Disk Intersection Problem
Example: The class CountyPop
Representing census-related data
Sorting a list of CountyPop objects
Visualizing a List of Points

```python
>>> P = Point(3,4);Q = Point(1,2);R = Point(9,3)
>>> L = [P,Q,R]
```

---

The diagram shows a list `L` containing three points: `P(3,4)`, `Q(1,2)`, and `R(9,3)`. The list is visualized with arrows pointing to the points, indicating the order as `P`, `Q`, and `R`.
Visualizing a List of ints

>>> L = [3, 1, 9]
A List of Objects

We would like to assemble a list whose elements are not numbers or strings, but references to objects.

For example, we have a hundred points in the plane and a length-100 list of points called ListOfPoints.

Let’s compute the average distance to (0,0).
Working with a List of Point Objects

Origin = Point(0,0)
d = 0
for P in ListOfPoints:
    d += P.Dist(Origin)
N = len(ListOfPoints)
AveDist = d/N

A lot of familiar stuff: Running sums. A for-loop based on “in”. The len function, Etc
def RandomCloud(Lx, Rx, Ly, Ry, n):
    """ Returns a length-n list of points, each chosen randomly from the rectangle Lx<=x<=Rx, Ly<=y<=Ry. 
    PreC: Lx and Rx are floats with Lx<Rx, Ly and Ry are floats with Ly<Ry, and 
    n is a positive int.  """

    A = []
    for k in range(n):
        P = RandomPoint(Lx, Rx, Ly, Ry)
        A.append(P)

    return A

The append method for lists works for lists of objects.
def RandomPoint(Lx,Rx,Ly,Ry):
    """ Returns a point that is randomly chosen from the square Lx<=x<=Rx, Ly<=y<=Ry. 
    """

    PreC: Lx and Rx are floats with Lx<Rx
    Ly and Ry are floats with Ly<Ry
    """

    x = randu(Lx,Rx)
    y = randu(Ly,Ry)
    P = Point(x,y)
    return P
Visualizing a List of Points

>>> P = Point(3,4);Q = Point(1,2);R = Point(9,3)
>>> L = [P,Q,R]
Visualizing a List of Points

>>> P = Point(3,4); Q = Point(1,2); R = Point(9,3)

>>> L = [P, Q, R]

More accurate: A List of references to Point objects
Operations on a List of Points

>>> L[1].x = 100

Before
Operations on a List of Points

>>> L[1].x = 100

After
Operations on a List of Points

>>> L[1] = Point(5,5)

Before
Operations on a List of Points

>>> L[1] = Point(5,5)

After
def printCloud(A):
    """ Prints the points in A
    """
    PreC : A is a list of points.
    """
    for a in A:
        print a

Synonym for the loop:

    for k in range(len(A)):
        print A[k]
We Now Showcase the Use of Lists of Objects

Example 1. A Disk Intersection Problem

Example 2. A Census Data Problem
A Disk Intersection Problem
An Intersection Problem

We have a 10-by-10 target

for k in range(100):
    Generate a random disk \( D \)
    Display \( D \) if it does not touch any of the previously displayed disks

Assume all the disks have radius 1 and all inside the target.
A Class for Representing Disks

class Disk(object):
    ""
    Attributes:
        center: Point, the center of the disk
        radius: float, the radius of the disk
    ""
    def __init__(self,P,r):
        """ Creates a Disk object with center P and radius r
        PreC: P is a Point,r is a pos float ""
        self.center = P
        self.radius = r

Note that an attribute can be an object. The center attribute is a Point.
The RandomDisk Function

def RandomDisk(n):
    ""
    Returns a random radius-1 disk whose
    center is inside the 2n-by-2n square
    centered at (0,0).
    Pre: n is a positive int
    ""
    x = randu(-n,n)
    y = randu(-n,n)
    center = Point(x,y)
    radius = 1
    return Disk(center,radius)
When Does a Pair of Disks Intersect?

Answer: When the distance between their centers is less than the sum of their radii.
The Method Intersects

def Intersects(self, other):
    """ Returns True if self and other intersect and False otherwise. 
    PreC: self and other are Disk objects """
    # The center-to-center distance:
    c1 = self.center
    c2 = other.center
    d = c1.Dist(c2)
    # The sum of the two radii
    radiusSum = self.radius + other.radius
    TheyIntersect = (radiusSum >= d)
    return TheyIntersect
An Intersection Problem

We have a 10-by-10 target

for k in range(100):
    Generate a random disk $D$
    Display $D$ if it does not touch any of the previously displayed disks

Assume all the disks have radius 1 and all inside the target.
def outsideAll(D0,L):
    """ Returns True if D0 doesn't intersect any of the disks in L
    """

    PreC: D0 is a Disk and L is a list of Disks
    """

    for D in L:
        if D.Intersects(D0):
            return False

    return True
Using outsideAll

# The list of displayed disks...

m = 10
DiskList = []
for k in range(100):
    D = RandomDisk(m-1)
    if outsideAll(D, DiskList):
        # D does not intersect any
        # of the displayed disks
        ShowDisk(D, MAGENTA)
        DiskList.append(D)

nDisplayed = len(DiskList)
A Census Data Sorting Problem
What Can We Sort?

We can sort a list of numbers from small to big (or big to small).

We can sort a list of strings from “A-to-Z” (or “Z-to-A”).

We can sort a list of objects based on an attribute if that attribute is either a number or a string.
A Sorting Problem

Suppose we have

class Student(object):
    Attributes:
        Name: string, student’s name
        GPA : float, student’s gpa

and that L is a list of Student objects...
A List of Student Objects

- **Gaga**
  - Name: 'Gaga'
  - GPA: 3.31

- **Cher**
  - Name: 'Cher'
  - GPA: 4.00

- **Adele**
  - Name: 'Adele'
  - GPA: 2.95
A List of Student Objects

We can sort this list based on Name or GPA.

L:

- L[0]: Student
  - Name: ‘Gaga’
  - GPA: 3.31

- L[1]: Student
  - Name: ‘Cher’
  - GPA: 4.00

- L[2]: Student
  - Name: ‘Adele’
  - GPA: 2.95
A List of Student Objects

- **Student**
  - Name: 'Adele'
  - GPA: 2.95
  - Index: L[0]

- **Student**
  - Name: 'Cher'
  - GPA: 4.00
  - Index: L[1]

- **Student**
  - Name: 'Gaga'
  - GPA: 3.31
  - Index: L[2]
A List of Student Objects

L:

L[0]  Student  Name: ‘Cher’  GPA: 4.00
L[1]  Student  Name: ‘Gaga’  GPA: 3.31
L[2]  Student  Name: ‘Adele’  GPA: 2.95

Sorted by GPA
How to Do We Do This?

You have to write a “getter” function that extracts the value of the “key” attribute.

The name of this getter function is then passed as an argument to the sort method.

We illustrate the technique on a problem that involves census data.
class CountyPop(object):
    """
    Attributes:
    Name: the name of the county (string)
    State: the name of the state (string)
    Pop2010: the 2010 population (int)
    Pop2011: the 2011 population (int)
    Pop2012: the 2012 population (int)
    Pop2013: the 2013 population (int)
    Pop2014: the 2014 population (int)
    """
Setting Up the List of CountyPop Objects

The file CensusData.csv has these columns:

5  State Name
6  County Name
7  2010 county population
10 2011 county population
11 2012 county population
12 2013 county population
13 2014 county population
TheCounties = fileToStringList('CensusData.csv')
L = []
for c in TheCounties:
    v = c.split(',',')
    c = CountyPop(v[6],v[5],int(v[7]),int(v[10]),
                  int(v[11]),int(v[12]),int(v[13]))
    L.append(C)

The constructor sets up the Name, State, Pop2010, Pop2011, Pop2012, Pop2013, and Pop2014 attributes
def getPop2014(C):
    # C is a County Object
    return C.Pop2014

if __name__ == '__main__':
    L.sort(key=getPop2014, reverse=True)
    for k in range(10):
        print L[k], L[k].Pop2014

This getter function grabs the 2014 population.

And here is how we tell sort to use it

Printing the top ten counties in the USA in terms of population.
## Top Ten in 2014

<table>
<thead>
<tr>
<th>County</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles County, California</td>
<td>10116705</td>
</tr>
<tr>
<td>Cook County, Illinois</td>
<td>5246456</td>
</tr>
<tr>
<td>Harris County, Texas</td>
<td>4441370</td>
</tr>
<tr>
<td>Maricopa County, Arizona</td>
<td>4087191</td>
</tr>
<tr>
<td>San Diego County, California</td>
<td>3263431</td>
</tr>
<tr>
<td>Orange County, California</td>
<td>3145515</td>
</tr>
<tr>
<td>Miami-Dade County, Florida</td>
<td>2662874</td>
</tr>
<tr>
<td>Kings County, New York</td>
<td>2621793</td>
</tr>
<tr>
<td>Dallas County, Texas</td>
<td>2518638</td>
</tr>
<tr>
<td>Riverside County, California</td>
<td>2329271</td>
</tr>
</tbody>
</table>