61A Lecture 18

Monday, October 8

Relationship to the Python Object System

Bonus Material

Object attributes are stored as dictionaries

Some special names, __<name>__, require special handling

An object has an "attribute" called __dict__ that is a dictionary of its user-defined instance attributes

Demo

In Python, classes have classes too

The equivalent of init_instance can be customized (metaclass)

Generic Functions

An abstraction might have more than one representation

- Python has many sequence types: tuples, ranges, lists, etc.

An abstract data type might have multiple implementations

- Some representations are better suited to some problems

A function might want to operate on multiple data types

Today's Topics:

- Generic functions using message passing
- String representations of objects
- Multiple representations of abstract data types
- Property methods

String Representations

An object value should **behave** like the kind of data it is meant to represent

For instance, by **producing a string** representation of itself

Strings are important: they represent *language* and *programs*

In Python, all objects produce two string representations

- The "str" is legible to **humans**
- The "repr" is legible to the **Python interpreter**

When the "str" and "repr" **strings are the same**, we're doing **something right** in our programming language!

The "repr" String for an Object

The repr function returns a Python expression (as a string) that evaluates to an equal object

```
repr(object) -> string

Return the canonical string representation of the object.
For most object types, eval(repr(object)) == object.
```

The result of calling repr on the value of an expression is what Python prints in an interactive session

```
>>> 12e12
120000000000000.0
>>> print(repr(12e12))
120000000000000.0
```

Some objects don't have a simple Python-readable string

```
>>> repr(min)
'<built-in function min>'
```


The "str" String for an Object

Human interpretable strings are useful as well

```
>>> import datetime
>>> today = datetime.date(2011, 10, 7)
>>> repr(today)
'datetime.date(2011, 10, 7)'
>>> str(today)
'2011-10-07'
```

Demo

Message Passing Enables Polymorphic Functions

Polymorhic function: A function that can be applied to many (*poly*) different forms (*morph*) of data

str and repr are both polymorphic; they apply to anything

repr invokes a zero-argument method __repr__ on its argument

```
>>> today.__repr__()
'datetime.date(2011, 10, 7)'
```

str invokes a zero-argument method __str__ on its argument

```
>>> today.__str__()
'2011-10-07'
```


Implementing repr and str

The behavior of repr is slightly more complicated than invoking __repr__ on its argument:

- An instance attribute called __repr__ is ignored (demo)
- **Question:** How would we implement this behavior?

The behavior of str:

- An instance attribute called __str__ is ignored
- If no __str__ attribute is found, uses repr string (demo)
- **Question:** How would we implement this behavior?
- str is a class, not a function

Interfaces

Message passing allows **different data types** to respond to the **same message**

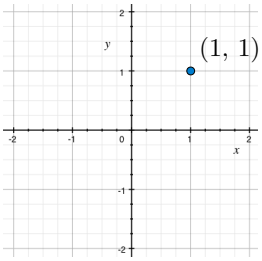
A shared message that elicits similar behavior from different object classes is a powerful method of abstraction

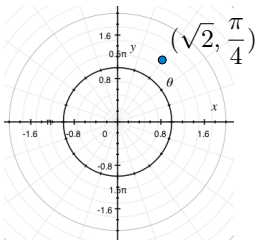
An *interface* is a **set of shared messages,** along with a specification of **what they mean**

Classes that implement __repr__ and __str__ methods *that return Python- and human-readable strings* thereby **implement an interface** for producing Python string representations

Multiple Representations of Abstract Data

Rectangular and polar representations for complex numbers

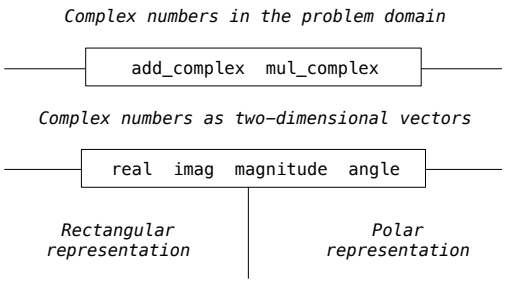




Most operations don't care about the representation

Some mathematical operations are easier on one than the other

Arithmetic Abstraction Barriers



An Interface for Complex Numbers

All complex numbers should produce real and imag components

All complex numbers should produce a magnitude and angle

Demo

Using this interface, we can implement complex arithmetic

```
>>> def add_complex(z1, z2):
        return ComplexRI(z1.real + z2.real,
                         z1.imag + z2.imag)

>>> def mul_complex(z1, z2):
        return ComplexMA(z1.magnitude * z2.magnitude,
                         z1.angle + z2.angle)
```

Property Methods

Often, we want the value of instance attributes to be linked

```
>>> f = Fraction(3, 5)
>>> f.float_value
0.6
>>> f.numer = 4
>>> f.float_value
0.8
>>> f.denom -= 3
>>> f.float_value
2.0
```

The @property decorator on a method designates that it will be called whenever it is *looked up* on an instance.

It allows zero-argument methods to be called without the standard call expression syntax

Demo

The Rectangular Representation

```
class ComplexRI(object):

    def __init__(self, real, imag):
        self.real = real
        self.imag = imag

    @property
    def magnitude(self):
        return (self.real ** 2 + self.imag ** 2) ** 0.5

    @property
    def angle(self):
        return atan2(self.imag, self.real)

    def __repr__(self):
        return 'ComplexRI({0}, {1})'.format(self.real,
                                            self.imag)
```

Property decorator: "Call this function on attribute look-up"

math.atan2(y,x): Angle between x-axis and the point (x,y)

The Polar Representation

```
class ComplexMA(object):

    def __init__(self, magnitude, angle):
        self.magnitude = magnitude
        self.angle = angle

    @property
    def real(self):
        return self.magnitude * cos(self.angle)

    @property
    def imag(self):
        return self.magnitude * sin(self.angle)

    def __repr__(self):
        return 'ComplexMA({0}, {1})'.format(self.magnitude,
                                            self.angle)
```


Using Complex Numbers

Either type of complex number can be passed as either argument to add_complex or mul_complex

```
>>> def add_complex(z1, z2):
        return ComplexRI(z1.real + z2.real,
                         z1.imag + z2.imag)

>>> def mul_complex(z1, z2):
        return ComplexMA(z1.magnitude * z2.magnitude,
                         z1.angle + z2.angle)


>>> from math import pi
>>> add_complex(ComplexRI(1, 2), ComplexMA(2, pi/2))
ComplexRI(1.0000000000000002, 4.0)
>>> mul_complex(ComplexRI(0, 1), ComplexRI(0, 1))
ComplexMA(1.0, 3.141592653589793)
```


Special Methods

Adding instances of user-defined classes use __add__ method

Demo

```
>>> ComplexRI(1, 2) + ComplexMA(2, 0)
ComplexRI(3.0, 2.0)
>>> ComplexRI(0, 1) * ComplexRI(0, 1)
ComplexMA(1.0, 3.141592653589793)
```

http://getpython3.com/diveintopython3/special-method-names.html

http://docs.python.org/py3k/reference/datamodel.html#special-method-names