61A Lecture 18

Monday, October 13

Announcements

- Homework 5 is due Wednesday 10/15 @ 11:59pm
  - Homework party Monday 10/13 6pm-8pm in 2050 VLSB
  - Homework is graded on effort; you don't need to spend 8 hours on one problem
- Project 3 is due Thursday 10/23 @ 11:59pm
- Midterm 2 is on Monday 10/27 7pm-9pm
  - Class Conflict? Fill out the conflict form at the top of http://cs61a.org
- Hog strategy contest winners will be announced on Wednesday 10/15 in Lecture
- Fireside chat with Dropbox CEO Drew Houston on Tuesday 10/14 @ 7pm in Wheeler

String Representations

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

The **str** and **repr** strings are often the same, but not always

The repr String for an Object

The **repr** function returns a Python expression (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 a value is what Python prints in an interactive session

```
>>> 12e12
12000000000000.0
>>> print(repr(12e12))
12000000000000.0
```

Some objects do not 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(2014, 10, 13)
>>> repr(today)
'datetime.date(2014, 10, 13)'
>>> str(today)
'2014-10-13'
```

The result of calling **str** on the value of an expression is what Python prints using the **print** function:

```
>>> print(today)
2014-10-13
```

(Demo)

Polymorphic Functions

Polymorphic Functions

Polymorphic function: A function that applies to many (poly) different forms (morph) of data

str and **repr** are both polymorphic; they apply to any object

repr invokes a zero-argument method __repr__ on its argument

```
>>> today.__repr__()
'datetime.date(2014, 10, 13)'
```

str invokes a zero-argument method __str__ on its argument

```
>>> today.__str__()
'2014-10-13'
```

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! Only class attributes are found
- *Question*: How would we implement this behavior?

The behavior of **str** is also complicated:

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

(Demo)

Interfaces

Message passing: Objects interact by looking up attributes on each other (passing messages)

The attribute look-up rules allow different data types to respond to the same message

A **shared message** (attribute name) 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

Example:

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

Property Methods

Property Methods

Often, we want the value of instance attributes to stay in sync

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

No method calls!

$$\frac{\begin{matrix}4\\ \cancel{3}\end{matrix}}{\begin{matrix}\cancel{5}\\ 2\end{matrix}}$$

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

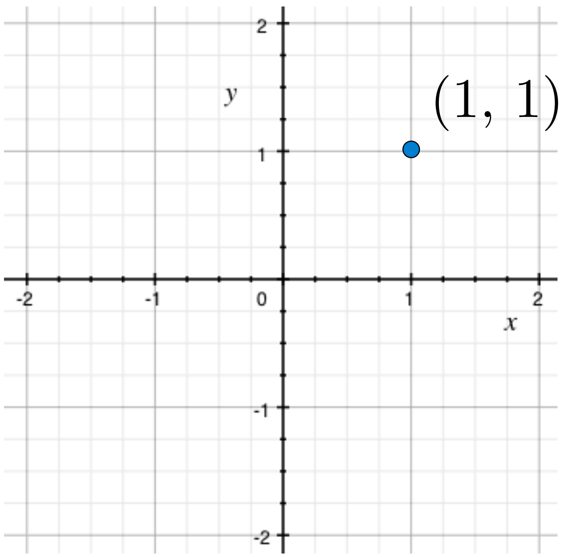
It allows zero-argument methods to be called without an explicit call expression

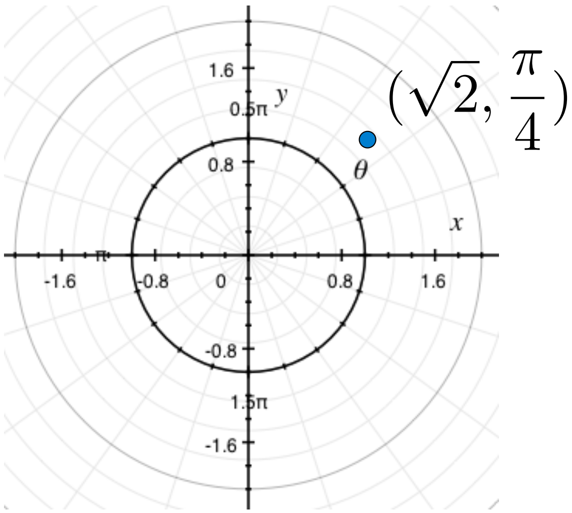
(Demo)

Example: Complex Numbers

Multiple Representations of Abstract Data

Rectangular and polar representations for complex numbers





Most programs don't care about the representation

Some arithmetic operations are easier using one representation than the other

Implementing Complex Arithmetic

Assume that there are two different classes that both represent Complex numbers

Number	Rectangular representation	Polar representation
$1 + \sqrt{-1}$	**ComplexRI**(1, 1)	**ComplexMA**(sqrt(2), pi/4)

Perform arithmetic using the most convenient representation

```
class Complex:
    def add(self, other):
        return ComplexRI(self.real + other.real,
                         self.imag + other.imag)
    def mul(self, other):
        return ComplexMA(self.magnitude * other.magnitude,
                         self.angle + other.angle)
```

Complex Arithmetic Abstraction Barriers

Parts of the program that...	Treat complex numbers as...	Using...
Use complex numbers to perform computation	whole data values	`x.add(y), x.mul(y)`
Add complex numbers	real and imaginary parts	`real, imag, ComplexRI`
Multiply complex numbers	magnitudes and angles	`magnitude, angle, ComplexMA`

Implementation of the Python object system

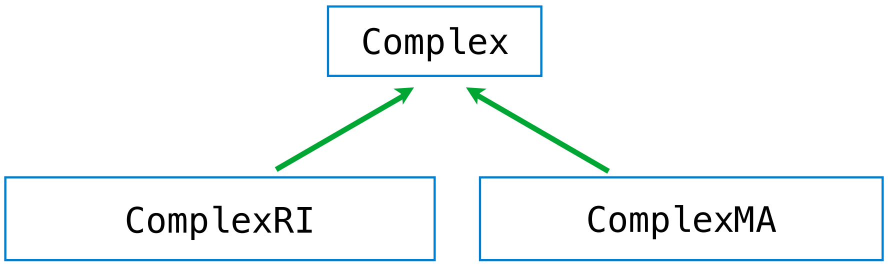
Implementing Complex Numbers

An Interface for Complex Numbers

All complex numbers should have `real` and `imag` components

All complex numbers should have a `magnitude` and `angle`

All complex numbers should share an implementation of `add` and `mul`



(Demo)

The Rectangular Representation

```
class ComplexRI:

    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 @property decorator allows zero-argument methods to be called without the standard call expression syntax, so that they appear to be simple attributes

The Polar Representation

```python
class ComplexMA:

    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 either argument to add or mul:

```
class Complex:
    def add(self, other):
        return ComplexRI(self.real + other.real,
                         self.imag + other.imag)
    def mul(self, other):
        return ComplexMA(self.magnitude * other.magnitude,
                         self.angle + other.angle)
```

```
>>> from math import pi
>>> ComplexRI(1, 2).add(ComplexMA(2, pi/2))
ComplexRI(1.0000000000000002, 4.0)
>>> ComplexRI(0, 1).mul(ComplexRI(0, 1))
ComplexMA(1.0, 3.141592653589793)
```

$1 + 4 \cdot \sqrt{-1}$

-1