61A Lecture 16

Monday, March 2
Announcements

• Homework 5 is due Wednesday 3/4 @ 11:59pm
  ▪ Homework/Project party Tuesday 3/3 5pm–6:30pm in 2050 VLSB
• Quiz 2 is due Thursday 3/5 @ 11:59pm
• Project 3 is due Thursday 3/12 @ 11:59pm
• Midterm 2 is on Thursday 3/19 7pm–9pm
• Hog strategy contest winners will be announced on Wednesday 3/4 in lecture
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

\[
\text{repr(object)} \rightarrow \text{string}
\]

Return the canonical string representation of the object. For most object types, \(\text{eval(repr(object))} == \text{object}\).

The result of calling `repr` on a value is what Python prints in an interactive session

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

Some objects do not have a simple Python-readable string

```python
>>> repr(min)
'\<built-in function min>\'
```
The str String for an Object

Human interpretable strings are useful as well:

```python
>>> 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:

```python
>>> print(today)
2014-10-13
```
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 \texttt{repr} is slightly more complicated than invoking \texttt{__repr__} on its argument:
- An instance attribute called \texttt{__repr__} is ignored! Only class attributes are found
- \textit{Question}: How would we implement this behavior?

The behavior of \texttt{str} is also complicated:
- An instance attribute called \texttt{__str__} is ignored
- If no \texttt{__str__} attribute is found, uses \texttt{repr} string
- \textit{Question}: How would we implement this behavior?
- \texttt{str} is a class, not a function
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

```python
>>> 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
```

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
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

<table>
<thead>
<tr>
<th>Number</th>
<th>Rectangular representation</th>
<th>Polar representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1 + \sqrt{-1}$</td>
<td>$\text{ComplexRI}(1, 1)$</td>
<td>$\text{ComplexMA}(\sqrt{2}, \pi/4)$</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Parts of the program that...</th>
<th>Treat complex numbers as...</th>
<th>Using...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use complex numbers to perform computation</td>
<td>whole data values</td>
<td>x.add(y), x.mul(y)</td>
</tr>
<tr>
<td>Add complex numbers</td>
<td>real and imaginary parts</td>
<td>real, imag, ComplexRI</td>
</tr>
<tr>
<td>Multiply complex numbers</td>
<td>magnitudes and angles</td>
<td>magnitude, angle, ComplexMA</td>
</tr>
</tbody>
</table>

*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 math.atan2(self.imag, self.real)

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


The @property decorator allows zero-argument methods to be called without the standard call expression syntax, so that they appear to be simple attributes
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:g}, {1:g} * pi)'.format(self.magnitude, self.angle / pi)
Using Complex Numbers

Either type of complex number can be either argument to `add` or `mul`:

```python
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, 4)                                           1+4·√−1
>>> ComplexRI(0, 1).mul(ComplexRI(0, 1))
ComplexMA(1, 1 * pi)                                       −1
```