# 61A Lecture 17

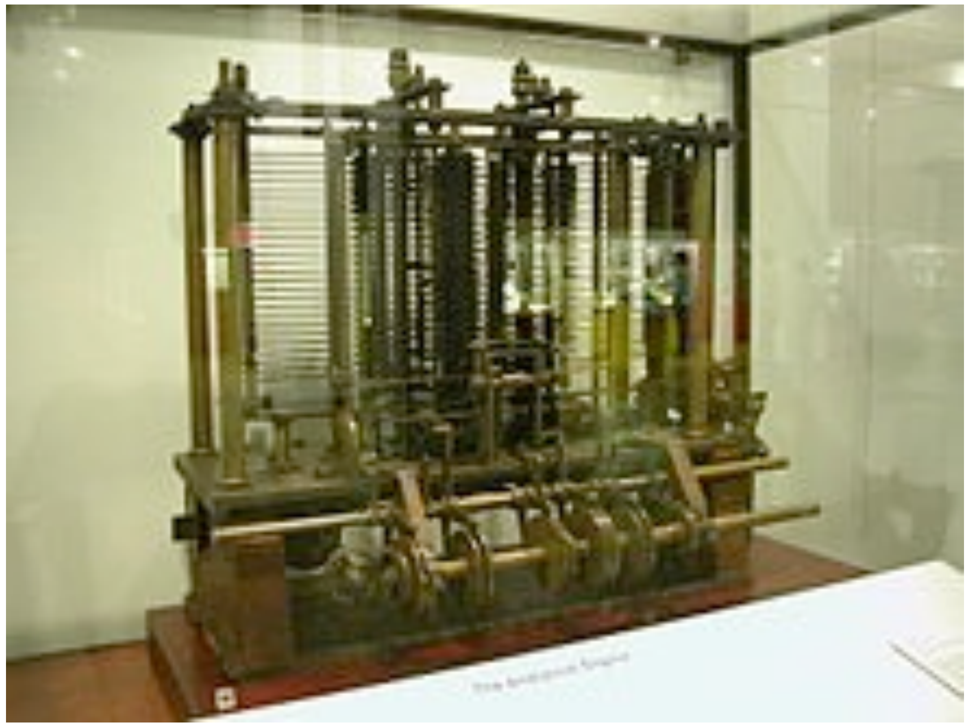
Friday, October 7

## Today is Ada Lovelace Day

Ada Lovelace, born 1815, was a writer, mathematician, and correspondent of Charles Babbage

Charles Babbage designed the "analytical engine"

Ada wrote its first program (to compute Bernoulli numbers)



Images from Wikipedia

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

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?

## Interfaces

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

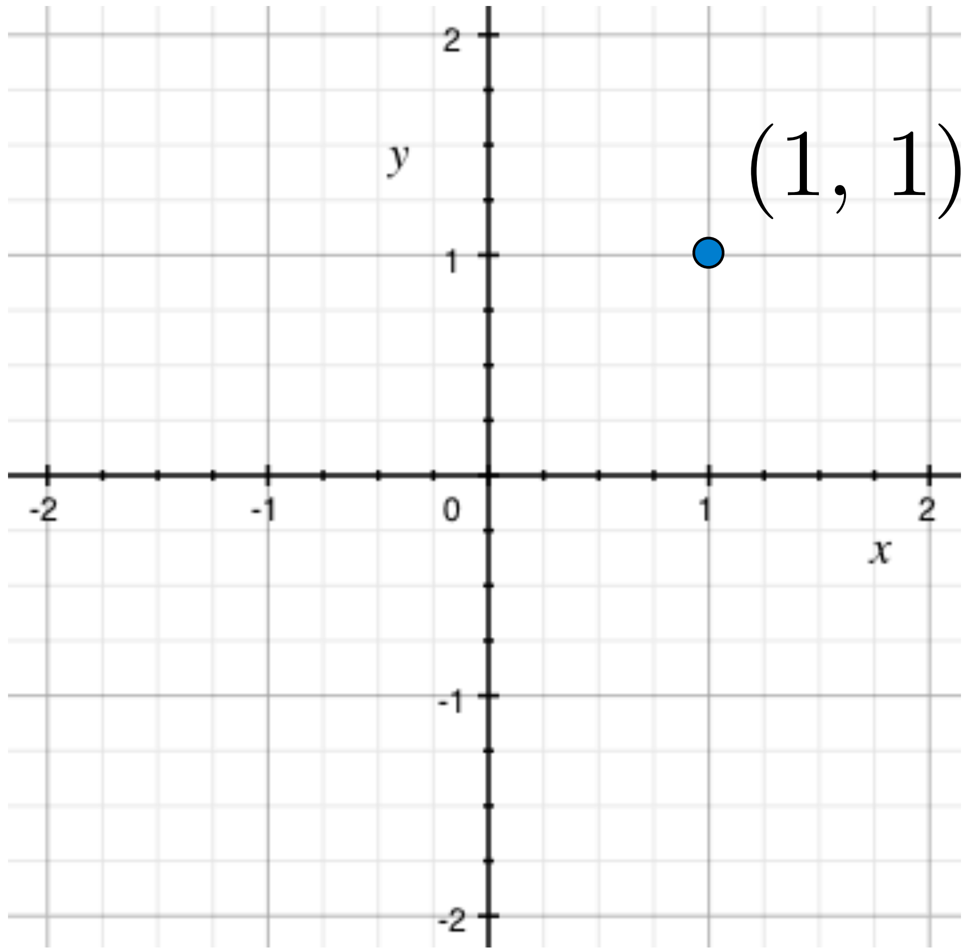
A shared message that elicits similar behavior from different object classes is a powerful method of abstraction

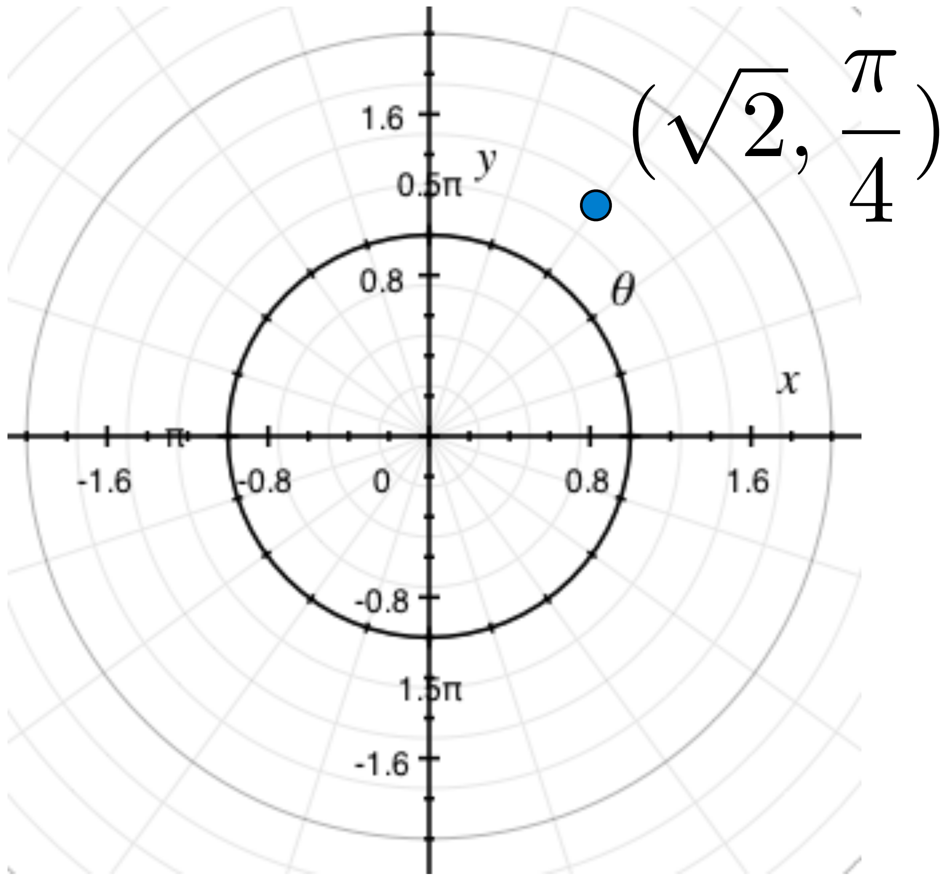
An *interface* is a **set of shared messages,** along with a specification of **what they mean**

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

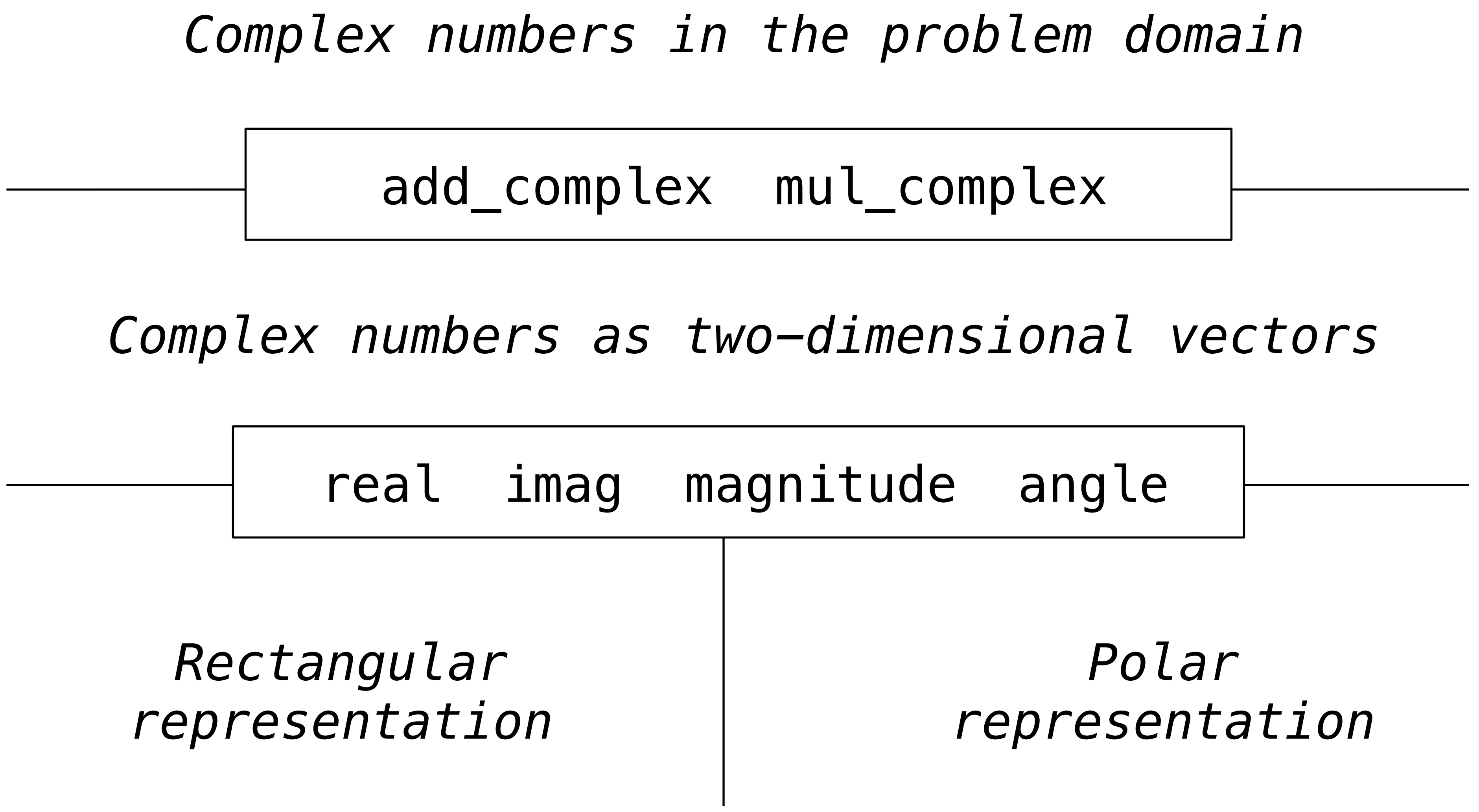




Most operations don't care about the representation

Some mathematical operations are easier on one than the other

## Arithmetic Abstraction Barriers


*Complex numbers in the problem domain*
add_complex mul_complex
*Complex numbers as two-dimensional vectors*
real imag magnitude angle
*Rectangular representation*
*Polar representation*

## 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)
```

## The Rectangular Representation

The @property decorator allows zero-argument methods to be called without the standard call expression syntax

```
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)
```

Special 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://diveintopython3.org/special-method-names.html

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