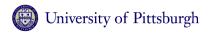
Object Oriented Programming

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Procedural Programming

Procedural programming: organising programs around functions.

Object-oriented programming: organising programs around objects.

Object Oriented Programming

OOP

Aggregation organise functions & data into classes.

Encapsulation hide information inside methods.

Polymorphism re-use code for multiple types.

Inheritance re-use code from one class to build another.

User-Defined Types

Built-in Types

- lists
- dictionaries
- strings
- 4 ...

Type

What's a Type

- A domain of values
- A set of methods (functions)

Examples of Types

List

- Domain: lists
- Functions: L.append(e),L.insert(idx,e), ...
- Operators: L[0], 'Rita' in L

Examples of Types

List

- Domain: lists
- Functions: L.append(e),L.insert(idx,e), . . .
- Operators: L[0], 'Rita' in L

Integer

- **●** Domain: ..., −2, 1, 0, 1, 2, ...
- Operators: A + B,...

User-defined Types

Object-oriented programming languages allow us to define new types.

Motivating Example

Simple Population Simulation

- We want to simulate a bacterial population.
- Our environment is a single float e.
- **③** Each bacterium has two characteristics: adaptation α and mutation rate σ .
- ① The smaller the difference $|\alpha e|$, the better an bacterium is adapted to the world.
- **1** When an bacterium reproduces, its offspring has adaptation $\alpha + \mathcal{N}(\mathbf{0}, \sigma)$
- At each iteration:
 - **①** Bacteria die with a probability given by $\beta \exp(-\beta |\alpha e|)$
 - Bacteria that survive, sometimes reproduce.

Bacteria World

Bacterium Class

We define a bacterium class, with two values:

- adaptation: its current adaptation value
- sigma: its variability parameter

and two methods:

- P_dead(environ): make a stochastic decision on whether the bacteriumdies
- 2 reproduce(): make a new bacterium, derived from current one

Using our Bacteria

```
population = [Bacterium()
        for i in xrange(nr inital bacteria)]
for i in xrange(max iters):
    bi = 0
    while bi < len(population):
        if population[bi].P dead(environ) < random():</pre>
            del population[bi]
        else:
            hi += 1
    N = len(population)
    for bi in xrange(N):
        if random() < p_reprod:</pre>
            population.append(population[bi].reproduce())
    if N >= max_population:
        shuffle (population)
        while len(population) >= max_population:
            population.pop()
```

Using our Bacteria

Classes As Logical Units

Class

A class aggregates data and functions that belong together.

Bacterium Interface

Interface

Functions:

- Constructor: Takes the initial adaptation value and sigma.
- P_dead(environ): Probability of dying in this environment.
- reproduce(): Return a new Bacterium.

Data elements:

- adaptation: Current adaptation.
- sigma: Current sigma.

```
class Bacterium(object):
    . . .
    Bacterium
    1 1 1
    def init (self, adaptation, sigma):
        self.adaptation = adaptation
        self.sigma = sigma
    def P dead(self,environ):
        1 1 1
        prob = bact.P_dead(environ)
        1 1 1
        return L*math.exp(-abs(self.adaptation-environ))
    def reproduce(self):
        111 111
        return Bacterium(self.adaptation +
                               normalvariate (0, self.sigma),
                               self.sigma)
    . . .
```

Calling Methods

Defining a method

Calling a Method

```
anim = Bacterium(random(), random())
anim.method(arg1, arg2)
```

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Simulation of Changing Bacteria

Why should only adaptation change? Why not sigma too?

Evolving Bacterium

```
class EvolveSigmaBacterium(object):
    111, 111
    def init (self,adapt,sigma,sigmasigma):
        self.adaptation = adapt
        self.sigma = sigma
        self.sigmasigma = sigmasigma
    def P_dead(self,environ):
        111,...111
        return L*math.exp(-
                math.abs(self.adaptation-environ)*L)
    def reproduce (self):
        111,...111
        return EvolveBacterium (
            self.adaptation + normalvariate(0, self.sigma),
            self.sigma + normalvariate(0, self.sigmasigma))
```

```
population = [EvolveSigmaBacterium()
        for i in xrange(nr_inital_bacteria)]
for i in xrange(max_iters):
    hi = 0
    while bi < len(population):</pre>
        if population[bi].P_dead(environ) < random():</pre>
            del population[bi]
        else:
            hi += 1
    N = len(population)
    for bi in xrange(N):
        if random() < p_reprod:</pre>
            population.append(population[bi].reproduce())
    if N >= max population:
        shuffle (population)
        while len(population) >= max population:
            population.pop()
```

Mixing populations

We can have a mixed population of σ -fixed and σ -changing bacteria!

```
population = [EvolveSigmaBacterium(random(), random(), 0.5)
        for i in xrange(nr_inital_bacteria//2)] + \
        [Bacterium(random(), random())
        for i in xrange(nr_inital_bacteria//2)]
for i in xrange(max_iters):
    bi = 0
    while bi < len(population):</pre>
        if population[bi].P_dead(environ) < random():</pre>
            del population[bi]
        else:
            hi += 1
    N = len(population)
    for bi in xrange(N):
        if random() 
            population.append(population[bi].reproduce())
    if N >= max population:
        shuffle (population)
        while len(population) >= max population:
            population.pop()
```

Polymorphism

Type Polymorphism

Code is polymorphic if it can use different types without change

Duck Typing



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Typical Polymorphism

Typical examples

- Actors in a simulation.
- File-like objects.
- Widgets.
- ...

Inheritance

The code for EvolveSigmaBacterium is very similar to the code for Bacterium.

```
class EvolveSigmaBacterium(Bacterium):
    A type of Bacterium, where $\sigma$ (which controls
    the rate of adaptative mutation) is itself subject
    to mutation (subject to sigma*sigmafact).
    Met.hods
        * Constructor:
        * P_dead(environ): inherited from Bacterium
        * reproduce():
    1.1.1
    def init (self, adaptation, sigma, sigmafact):
        Bacterium. init (self, adaptation, sigma)
        self.sigmafact = sigmafact
    def reproduce(self):
        111, 111
        return EvolveSigmaBacterium (
           self.adaptation + nv(0, self.sigma),
```

self.sigma + nv(0, self.sigma*self.sigmafact)

Lyskov Substitution Principle

If D inherits from C, then you should be able to use D anywhere you previously used C.

Behaves-Like

If D inherits from C, then D should behave-like C.

New-Style vs. Old-Style Classes

```
class Bacterium(object):
    ...
```

Are we inheriting from object?

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