

CLASSES AND OBJECTS



Outline

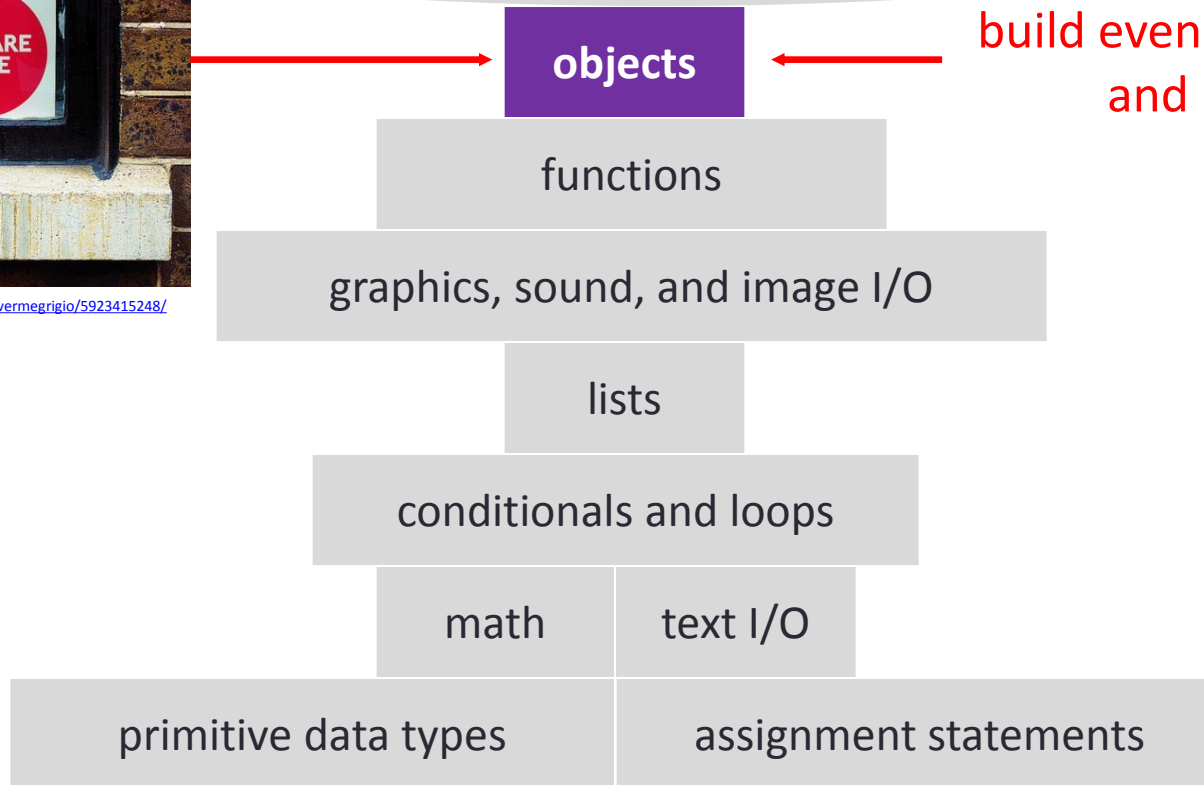
- Simple types
- Creating your own data types
 - Classes
 - Objects
 - Constructors
 - Attributes
 - Methods
 - Lists of objects

A Foundation for Programming

any program you might want to write



<http://www.flickr.com/photos/vermegriego/5923415248/>



Python Simple Types

Python type	what it stores	examples
int	integer values	42 1234
float	less precise floating-point values	9.95 3.0e8
boolean	truth values	True False
string	characters	'a', 'b', 'Hello!'

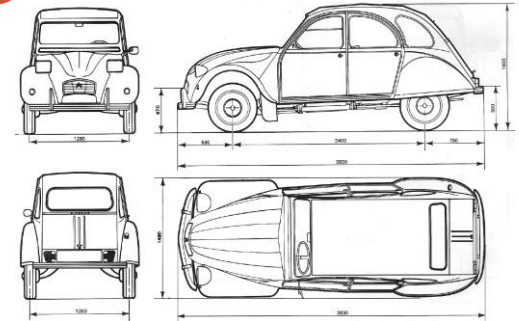
Simple Types: Limitations

- Simple types
 - Limited set of operations
 - Example: `int` data type operations: add, subtract, multiply, divide, modulo
 - Can't easily combine related information
 - e.g. `MarsLander`:
 - two `float`'s to represent your Mars lander's position
 - another two for velocity, etc.



Create Your Own Data Types

- **Class**
 - **Blueprint** for a custom data type
- **Object**
 - **Instance** of a class
 - May be multiple objects for a particular class blueprint



- Objects have **a set of things they know (“state”)**
 - Color of different body panels, location, fuel remaining
- Objects have **a set of things they can do (“behavior”)**
 - Honk horn
 - Turn on lights
 - Drive forward

Let's Build a Simple Class

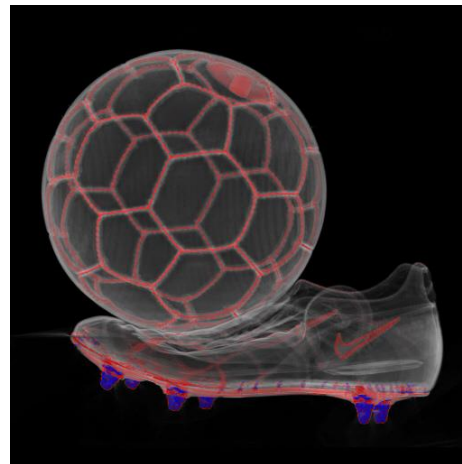
- **Goal: represent a circle in 2D**
 - **What does a circle need to know?**
 - x-coordinate
 - y-coordinate
 - radius
 - **What can a circle do?**
 - Draw itself
 - Print out its position and radius



Setting up the Circle Class

- Create `Circle.py` containing Circle class

```
class Circle:
```



Hello Constructors

- Add a **constructor**, creates and **initializes** attributes

```
class Circle:
```

```
    # Construct a Circle object at the given (x, y) position with radius r
    def __init__(self, x = 0.0, y = 0.0, r = 0.0):
        self.posX = x
        self.posY = y
        self.radius = r
        self.color = color.Color(224, 173, 255)
```

constructor:

Function name `__init__`.
This is a requirement!

Adding a Method

- Add **methods** for what a **Circle** can do

```
class Circle:
...

# Draw this Circle its location in its current color
def draw(self):
    StdDraw.setPenColor(self.color)
    StdDraw.filledCircle(self.posX, self.posY, self.radius)

# Text representation of this Circle
def toString(self):
    return "(" + str(self.posX) + ", " + str(self.posY) + ") r = " +
str(self.radius)
```

Let's try out our new class!

- Instantiating objects

```
import Circle
import random
import StdDraw

# Declare and instantiate the two circle objects
big = Circle.Circle()
small = Circle.Circle()

# Change both Circles from the default color
big.setColor(random.randint(0, 255), random.randint(0, 255))
small.setColor(random.randint(0, 255), random.randint(0, 255))

# Draw them on the screen
big.draw()
small.draw()
StdDraw.show(500)
```

"Build me a Circle object,
I'm not sending you any
input about how to do it."

Let's try out our New Class!

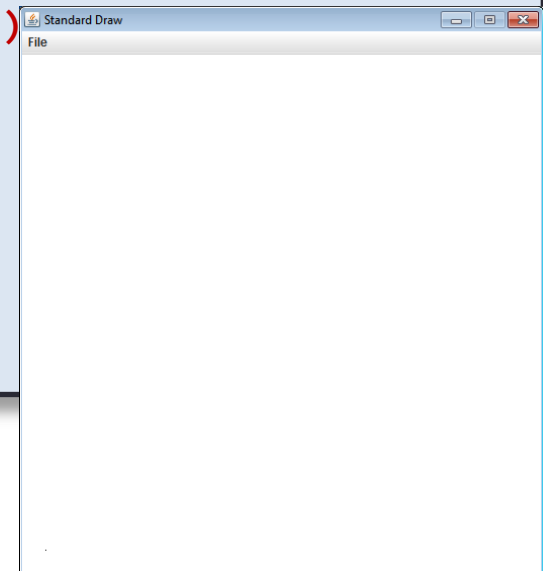
- Instantiating objects

```
# Declare and instantiate the two circle objects
big = Circle.Circle()
small = Circle.Circle()

# Change both Circles from the default color
big.setColor(random.randint(0, 255), random.randint(0, 255), random.randint(0, 255))
small.setColor(random.randint(0, 255), random.randint(0, 255),
255))

# Draw them on the screen
big.draw()
small.draw()
StdDraw.show(500)
```

```
% python LimitedCircleClient.py
big: (0.0, 0.0) r = 0.0
small: (0.0, 0.0) r = 0.0
```



CircleClient Take Two

- **Constructor called** when we create objects

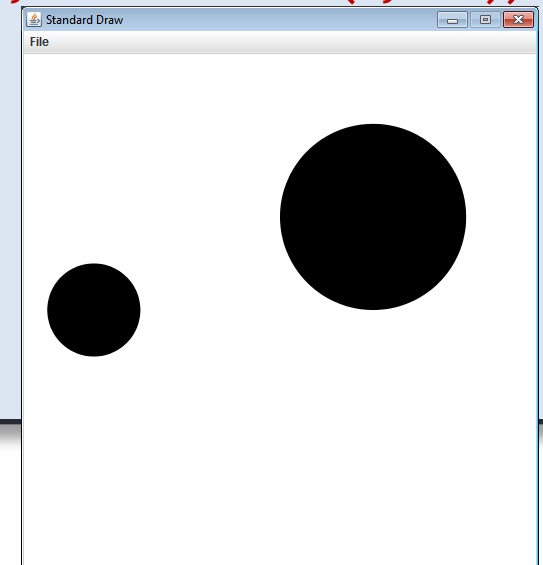
```
# Declare and instantiate the two circle objects
big = Circle.Circle(0.7, 0.7, 0.2)
small = Circle.Circle(0.1, 0.5, 0.1)

# Change both Circles from the default color
big.setColor(random.randint(0, 255), random.randint(0, 255), random.randint(0, 255))
small.setColor(random.randint(0, 255), random.randint(0, 255), random.randint(0, 255))

# Draw them on the screen
big.draw()
small.draw()

print("big: " + big.toString())
print("small: " + small.toString())
```

```
Stdout % python CircleClient.py
big: (0.7, 0.7) r = 0.2
small: (0.1, 0.5) r = 0.1
```



Colored Circles

- **Goal:** make each Circle object have a color specified by an red-green-blue (RGB) value
- Call `StdDraw.setPenColor()` in `draw()`
 - Create a new `Color` object for a given RGB value
 - `Color` is a class in the color library
 - Default color for our Circle objects: [mauve](#)



Circle in Living Color

```
import color
```

```
class Circle:
```

```
    # Construct a Circle object at the given (x, y) position with radius r
```

```
    def __init__(self, x = 0.0, y = 0.0, r = 0.0):
```

```
        self.posX    = x
```

```
        self.posY    = y
```

```
        self.radius  = r
```

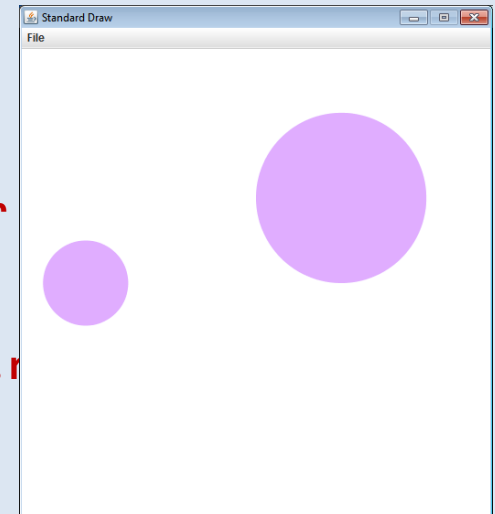
```
        self.color   = color.Color(224, 173, 255)
```

```
    # Draw this Circle its location in its current color
```

```
    def draw(self):
```

```
        StdDraw.setPenColor(self.color)
```

```
        StdDraw.filledCircle(self.posX, self.posY, self.radius)
```



Allowing Clients to Change Color

```
import color

class Circle:

    # Construct a Circle object at the given (x, y) position with radius r
    def __init__(self, x = 0.0, y = 0.0, r = 0.0):
        self.posX    = x
        self.posY    = y
        self.radius  = r
        self.color   = color.Color(224, 173, 255)

    # Draw this Circle its location in its current color
    def draw(self):
        StdDraw.setPenColor(self.color)
        StdDraw.filledCircle(self.posX, self.posY, self.radius)

    # Change the color of this Circle given an RGB pair where r, g, b are
    # in [0, 255]
    def setColor(self, r, g, b):
        self.color = color.Color(r, g, b)
```


Client Setting Random Color

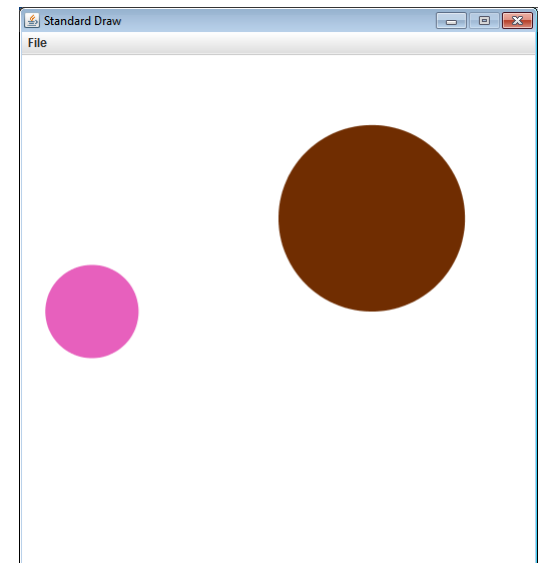
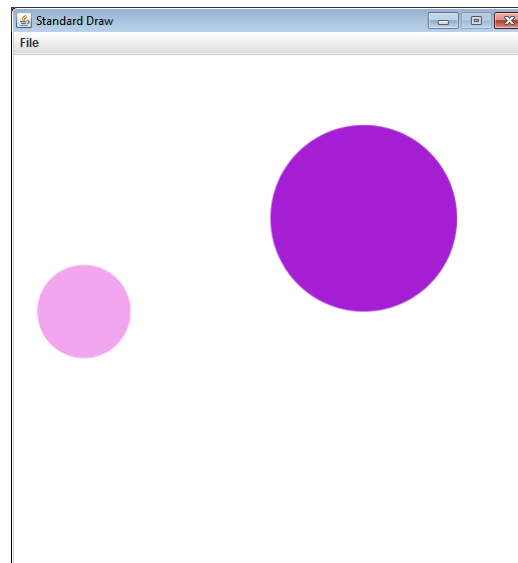
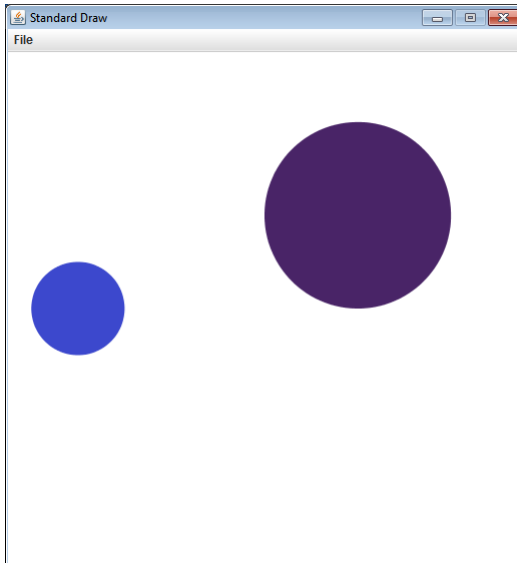
```
import random
```

```
...
```

```
# Change both Circles from the default color
```

```
big.setColor(random.randint(0, 255), random.randint(0, 255), random.randint(0, 255))
```

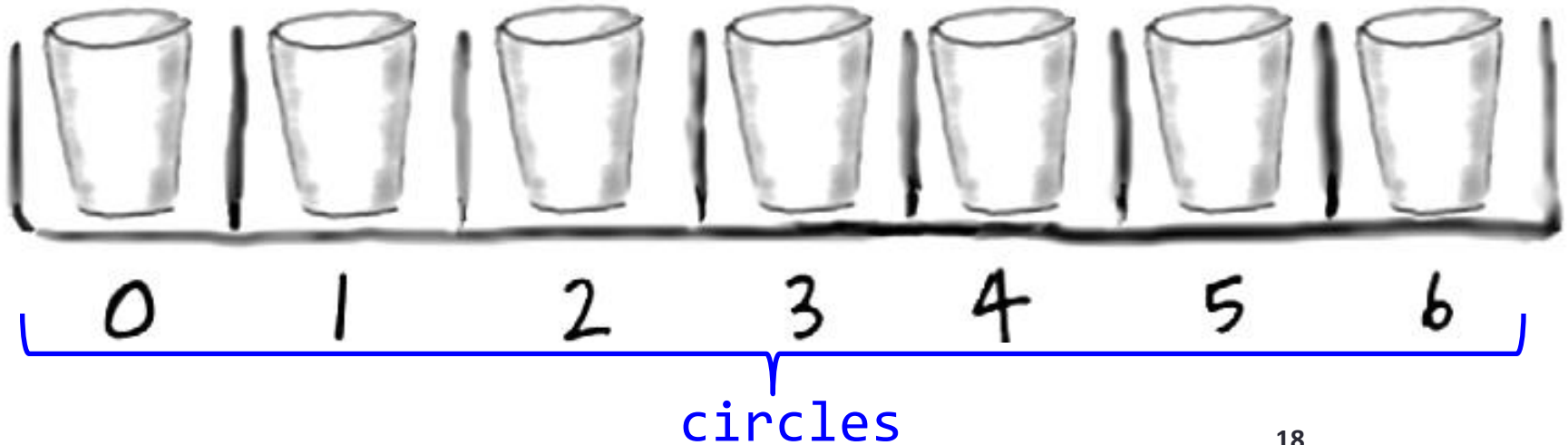
```
small.setColor(random.randint(0, 255), random.randint(0, 255), random.randint(0, 255))
```



Creating Lots of Circles

- We can have an **list of objects**
- **Step 1:** create an list

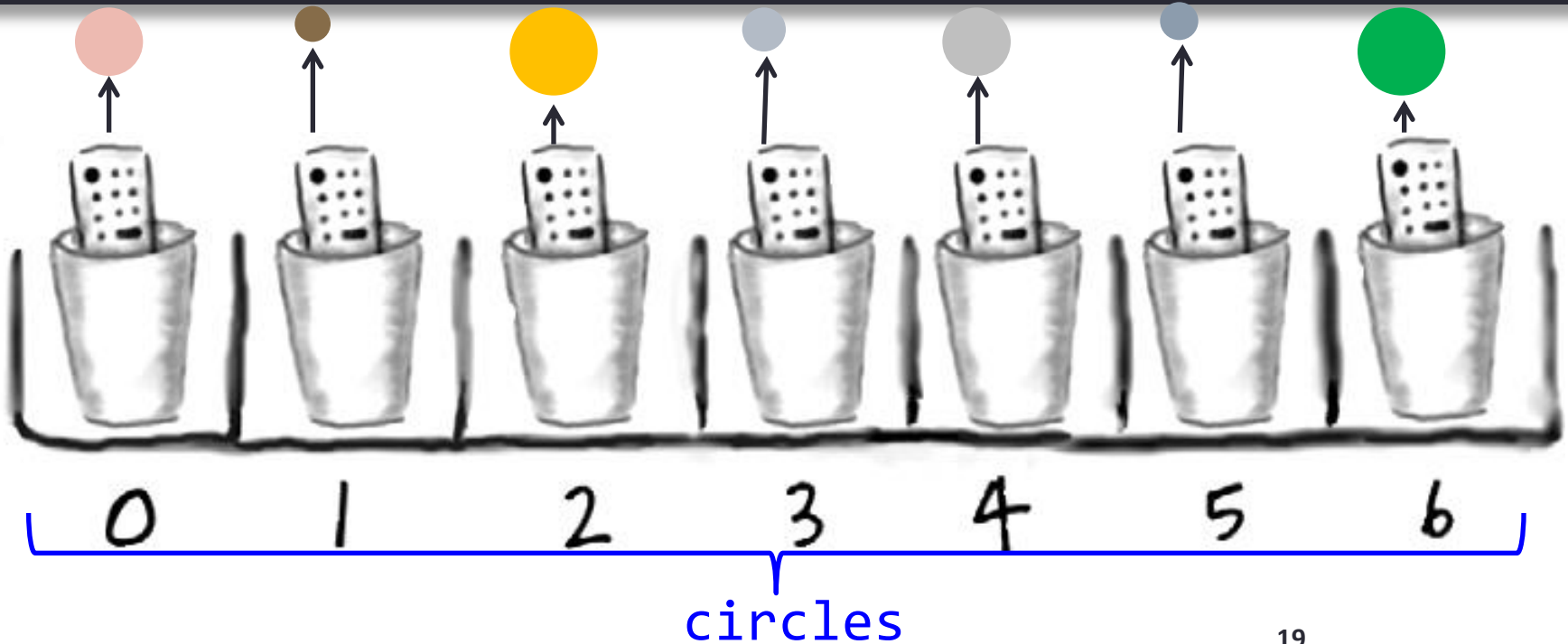
```
circles = []
```



Creating all the circle Objects

- Each array location needs a new object

```
circles = []  
for i in range(0, int(sys.argv[1])):  
    circles.append(Circle.Circle(random.random(), random.random(), random.random()*0.2))
```



Client to Draw Lots of circle Objects

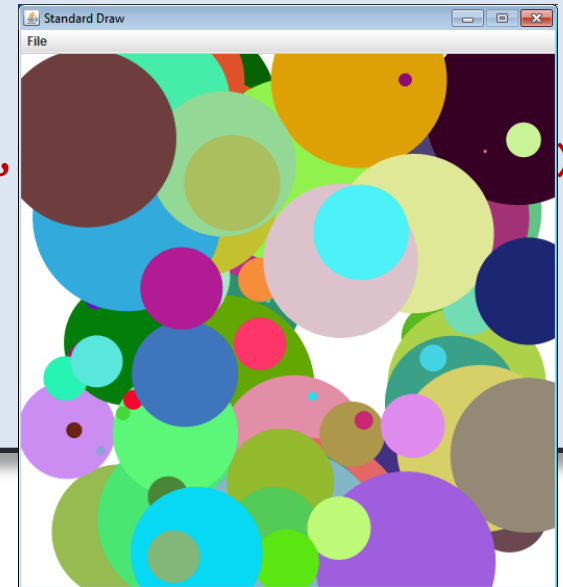
```
import Circle
import sys
import random
import StdDraw

# We create as many Circles as user specifies on command line
circles = []
for i in range(0, int(sys.argv[1])):
    circles.append(Circle.Circle(random.random(), random.random(), random.random()*0.2))

for circle in circles:
    # Set this new Circle to a random color
    circle.setColor(random.randint(0,255), random.randint(0,255), random.randint(0,255))

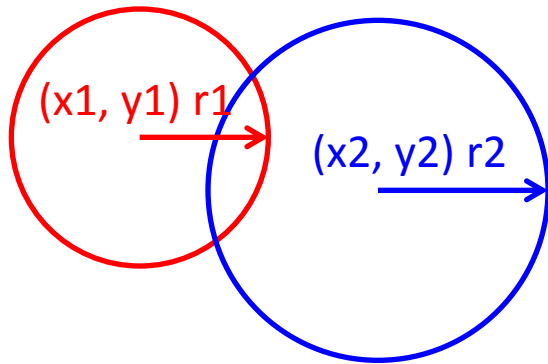
    # Draw it on the screen
    circle.draw()
StdDraw.show(50)
```

```
% python CircleClientDeluxe.py 100
```



Overlap Detection

- **Goal:** draw many `Circle` objects without overlap
 - When do two circles overlap?



Euclidean distance between centers:

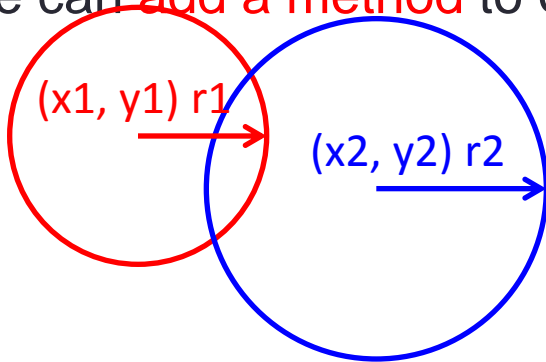
$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Circles overlap if:

$$d < (r_1 + r_2)$$

Implementing Overlap Detection

- Overlap detection is **something a Circle can do**
 - We can **add a method** to Circle class for this!



Euclidean distance between centers:

$$d = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}$$

Circles overlap if:

$$d < (r1 + r2)$$

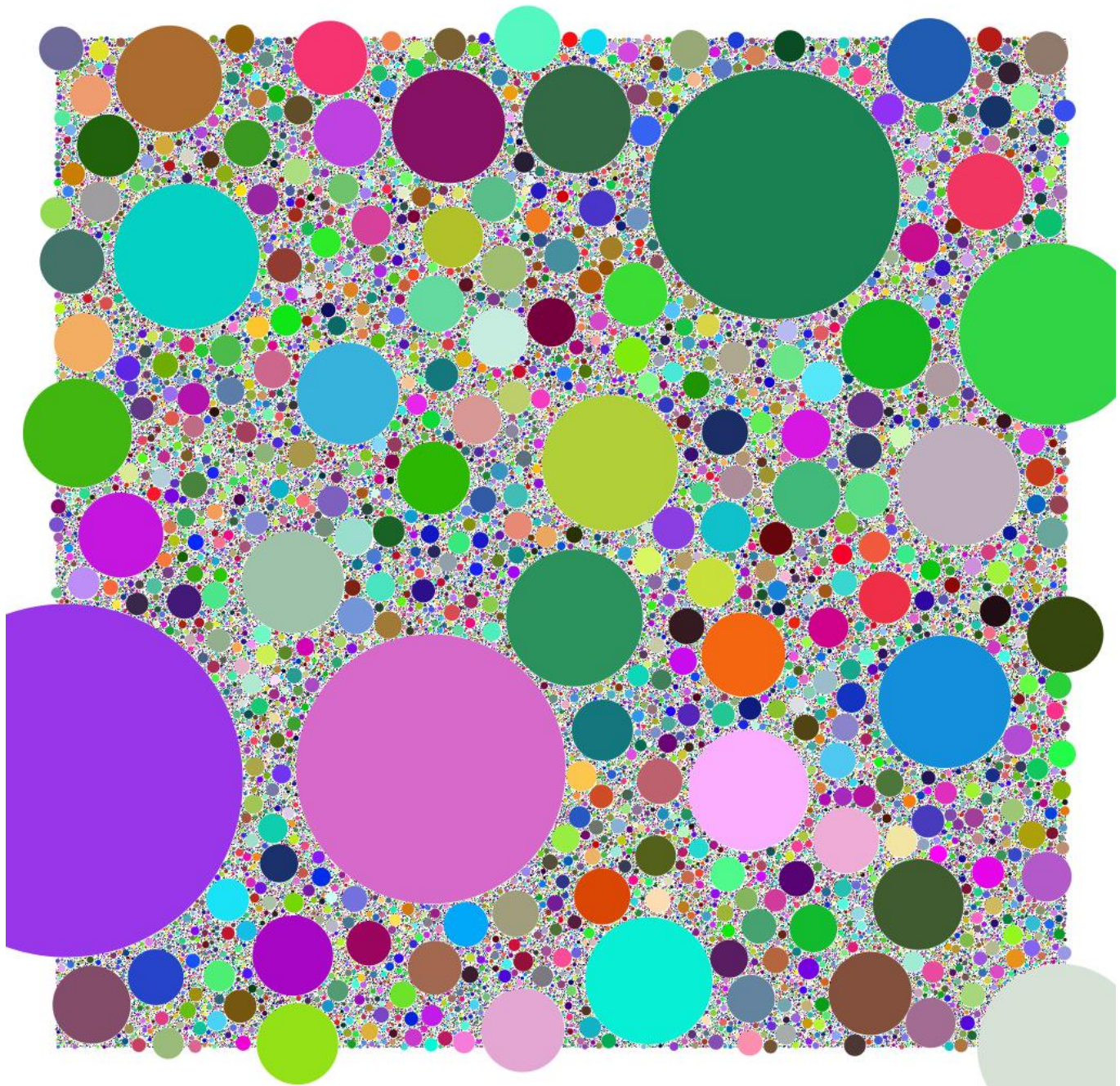
```
# Figure out if this circle and another circle overlap
def overlap(self, other):
    deltaX = self.posX - other.posX
    deltaY = self.posY - other.posY
    d = math.sqrt(deltaX**2 + deltaY**2)
    if d < (self.radius + other.radius):
        return True
    return False
```

CircleClientSuperDeluxe

```
import Circle
import sys
import random
import StdDraw

def overlapAny(circles, circle):
    result = False
    for i in range(0, len(circles)):
        if circles[i].overlap(circle):
            return True
    return result

# We create as many Circles as user specifies on command line
circles = []
for i in range(0, int(sys.argv[1])):
    newCircle = Circle.Circle(random.random(), random.random(), random.random()*0.2)
    while overlapAny(circles, newCircle):
        newCircle = Circle.Circle(random.random(), random.random(), random.random()*0.1)
    newCircle.setColor(random.randint(0,255), random.randint(0,255), random.randint(0,255))
    circles.append(newCircle)
    newCircle.draw()
    StdDraw.show(10)
StdDraw.show(2000)
```

Recap

- **Creating your own data types**
 - Object-oriented programming (OOP)
 - Design classes encapsulating:
 - **What objects know (“state”)**
 - **What objects can do (“behavior”)**
 - Prevalent concept in most modern programming languages

Summary

- Simple types
- Creating your own data types
 - Classes
 - Objects
 - Constructors
 - Attributes
 - Methods
 - Lists of objects

