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CSCI 121

Handout #5
February 4, 2019

Simple Graphics

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February 4, 2018

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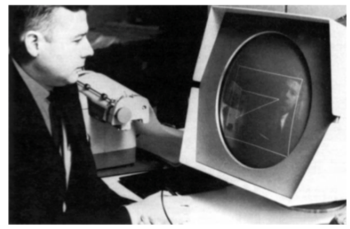
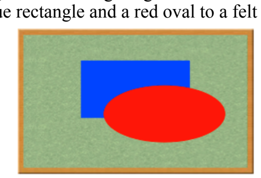


Turing Award winner Ivan Sutherland (who now lives in Portland) created the first graphical user interface as part of his 1963 MIT doctoral thesis on *Sketchpad*. This image, however, also features the DEC PDP-1. . . .

SPACEWAR!

The Graphics Model

- The Portable Graphics Library (`pgl.py`) uses a model based on the metaphor of a ***collage***.
- A collage is similar to a child's felt board that serves as a backdrop for colored shapes that stick to the felt surface. As an example, the following diagram illustrates the process of adding a blue rectangle and a red oval to a felt board:

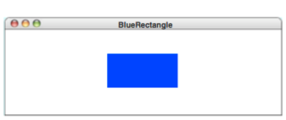


- Note that newer objects can obscure those added earlier. This layering arrangement is called the ***stacking order***.

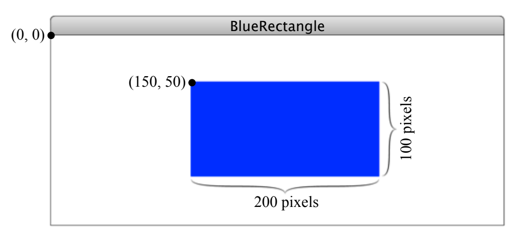
The `BlueRectangle` Program

```
def BlueRectangle():
    gw = GWindow(500, 200)
    rect = GRect(150, 50, 200, 100)
    rect.setColor("Blue")
    rect.setFilled(True)
    gw.add(rect)
```

rect



The Coordinate System



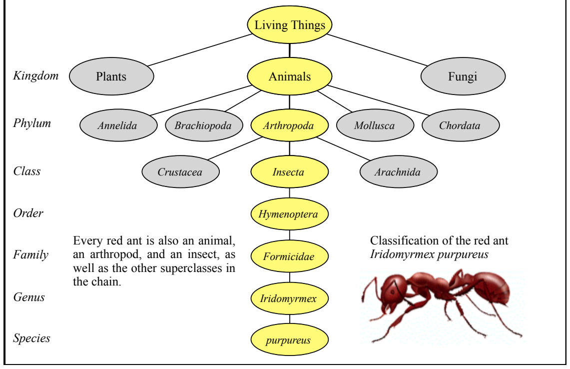
- Positions and distances on the screen are measured in terms of ***pixels***, which are the small dots that cover the screen.
- Unlike traditional mathematics, the graphics library defines the ***origin*** to be in the upper left corner. Values for the *y* coordinate increase as you move downward.

Systems of Classification

- In the mid-18th century, the Scandinavian botanist Carl Linnaeus revolutionized the study of biology by developing a new system for classifying plants and animals in a way that revealed their structural relationships and paved the way for Darwin's theory of evolution a century later.
- Linnaeus's contribution was to recognize that organisms fit into a hierarchy in which the placement of individual species reflects their anatomical similarities.

Carl Linnaeus (1707–1778)

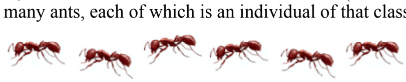
Biological Class Hierarchy



Instances *vs.* Patterns

Drawn after you, you pattern of all those.
—William Shakespeare, Sonnet 98

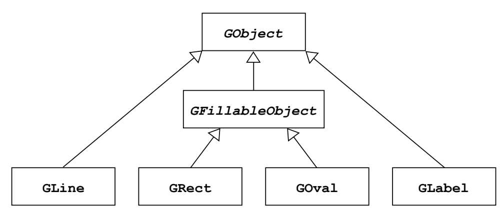
- In thinking about any classification scheme—biological or otherwise—it is important to draw a distinction between a class and specific instances of that class. In the most recent example, the designation *Iridomyrmex purpureus* is not itself an ant, but rather a ***class*** of ant. There can be (and usually are) many ants, each of which is an individual of that class.



- Each of these red ants is an ***instance*** of a particular class of ants. Each instance is of the species *purpureus,* the genus *Iridomyrmex,* the family *Formicidae* (which makes it an ant), and so on. Thus, each ant is not only an ant, but also an insect, an arthropod, and an animal.

The `GObject` Hierarchy

- The classes that represent graphical objects form a hierarchy, part of which looks like this:



- The `GObject` class represents the collection of all graphical objects. The `GFillableObject` class unifies those objects that have a fillable interior.

Creating a `GWindow` Object

- The first step in writing a graphical program is to create a window using the following function declaration, where *width* and *height* indicate the size of the window:

gw = GWindow(*width***,** *height***)**

- The following operations apply to a `GWindow` object:

gw.add(*object***)** Adds an object to the window.
gw.add(*object***,** *x***,** *y***)** Adds an object to the window after first moving it to (*x*, *y*).
gw.remove(*object***)** Removes the object from the window.
gw.getWidth() Returns the width of the graphics window in pixels.
gw.getHeight() Returns the height of the graphics window in pixels.

Operations on the `GObject` Class

- The following operations apply to all `GObject`s:

*object***.getX()** Returns the *x* coordinate of this object.
*object***.getY()** Returns the *y* coordinate of this object.
*object***.getWidth()** Returns the width of this object.
*object***.getHeight()** Returns the height of this object.
*object***.setColor(***color***)** Sets the color of the object to the specified color.

- All coordinates and distances are measured in pixels.
- Each color is a string, such as `"Red"` or `"White"`. The names of the standard colors are defined in Chapter 3.

Drawing Geometrical Objects

Functions to create geometrical objects:

`GRect(` *x*`,` *y*`,` *width*`,` *height*`)`
Creates a rectangle whose upper left corner is at (*x*, *y*) of the specified size.

`GOval(` *x*`,` *y*`,` *width*`,` *height*`)`
Creates an oval that fits inside the rectangle with the same dimensions.

`GLine(` x_0`,` y_0`,` x_1`,` y_1`)`
Creates a line extending from (x_0, y_0) to (x_1, y_1).

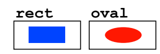
Methods shared by the `GFillableObject` subclasses:

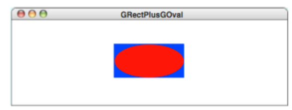
object`.setFilled(`*fill*`)`
If *fill* is `True`, fills in the interior of the object; if `False`, shows only the outline.

object`.setFillColor(`*color*`)`
Sets the color used to fill the interior, which can be different from the border.

The `GRectPlusGOval` Program

```
def GRectPlusGOval():
    gw = GWindow(500, 200)
    rect = GRect(150, 50, 200, 100)
    rect.setFilled(True)
    rect.setColor("Blue")
    gw.add(rect)
    oval = GOval(150, 50, 200, 100)
    oval.setFilled(True)
    oval.setColor("Red")
    gw.add(oval)
```



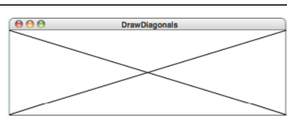


The `DrawDiagonals` Program

```
# Constants
GWINDOW_WIDTH = 500
GWINDOW_HEIGHT = 200

# Function: DrawDiagonals

def DrawDiagonals():
    gw = GWindow(GWINDOW_WIDTH, GWINDOW_HEIGHT)
    gw.add(GLine(0, 0, GWINDOW_WIDTH, GWINDOW_HEIGHT))
    gw.add(GLine(0, GWINDOW_HEIGHT, GWINDOW_WIDTH, 0))
```



The `GLabel` Class

You can display a string in the graphics window using the `GLabel` class, as illustrated by the following function that displays the string `"hello, world"` on the graphics window:

```
def HelloWorld():
    gw = GWindow(GWINDOW_WIDTH, GWINDOW_HEIGHT)
    label = GLabel("hello, world", 100, 75)
    label.setFont("36px 'Helvetica Neue','SansSerif'")
    label.setColor("Red")
    gw.add(label)
```

Operations on the `GLabel` Class

Function to create a `GLabel`

`GLabel(`*text*`,` *x*`,` *y*`)`
Creates a label containing the specified text that begins at the point (*x*, *y*).

Methods specific to the `GLabel` class

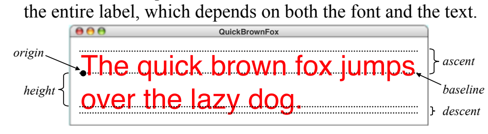
label`.setFont(`*font*`)`
Sets the font used to display the label as specified by the font string.

The font is a string composed of the following components

- The ***font style***, which is usually missing or `italic`.
- The ***font weight***, which is usually missing or `bold`.
- The ***font size***, which is a number followed by a suffix indicating the units (typically `pt`, `px`, or `em`).
- The ***font family***, which is the name of the font. Because the set of fonts differs on different machine, the family is usually a sequence of fonts separated by commas, which typically ends with a standard family: `serif`, `sans-serif`, or `monospaced`.

The Geometry of the `GLabel` Class

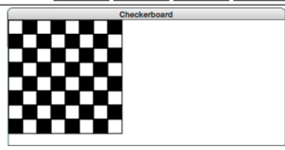
- The `GLabel` class relies on a set of geometrical concepts that are derived from classical typesetting:
  - The ***baseline*** is the imaginary line on which the characters rest.
  - The ***origin*** is the point on the baseline at which the label begins.
  - The ***height*** of the font is the distance between successive baselines.
  - The ***ascent*** is the distance characters rise above the baseline.
  - The ***descent*** is the distance characters drop below the baseline.
- You can use the `getHeight`, `getAscent`, and `getDescent` methods to determine the corresponding property of the font. You can use the `getWidth` method to determine the width of the entire label, which depends on both the font and the text.



Program to Draw a Checkerboard

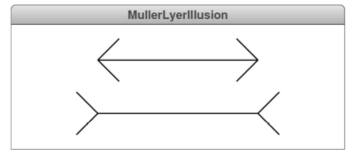
```
def Checkerboard():
    gw = GWindow(GWINDOW_WIDTH, GWINDOW_HEIGHT)
    for i in range(N_ROWS):
        y = i * SQUARE_SIZE
        for j in range(N_COLUMNS):
            x = j * SQUARE_SIZE
            sq = GRect(x, y, SQUARE_SIZE, SQUARE_SIZE)
            sq.setFilled((i + j) % 2 != 0)
            gw.add(sq)
```

gw	i	j	x	y	sq



Exercise: The Müller-Lyer Illusion

- Exercise 10 on page 114 describes the ***Müller-Lyer illusion,*** which asks the viewer which of the two horizontal lines is longer in the following figure:



- Work with your neighbor to write the program to create this image. As a first step, figure out what constants you need to define to control the sizes and positioning of the components.