Pygame tutorial Documentation

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Contents:

This tutorial explains how to make interactive applications and games using Pygame. The first part is a general introduction to Pygame without defining classes and objects. The second part introduces classes and objects and teaches an **object-oriented programming** approach to making apps.

CHAPTER 1

Introduction to Pygame

Pygame is a multimedia library for Python for making:

- games
- multimedia applications

It is a wrapper around the SDL (Simple DirectMedia Layer) library. In this section we indroduce the basics of pygame functions without defining classes and objects.

1.1 Import the module

In order to use the methods defined in the pygame package, the pygame module must first be imported:

```
import pygame
```

The import statement writes the pygame version and the following text to the console:

```
pygame 1.9.5
Hello from the pygame community. https://www.pygame.org/contribute.html
```

The pygame import statement is always placed at the beginning of the program. The effect is to import pygame classes, methods and attributes into the current name space. Now this new methods can be called via `pygame.method_name()`.

For exemple we can now initialize the pygame submodules with the following command:

```
pygame.init()
```

Then we set the screen size with the function `display.set_mode()`. This function returns a `Surface` object wich we assign to the variable `screen`. This variable will be one of the most important and most used variables. It is the one variable which represents what we see in the application:

```
screen = pygame.display.set_mode((640, 240))
```

You can now run this program and test it. At this moment it does very little. It opens a window and closes it immediately.

1.2 Show the event loop

One of the essential parts of any interactive application is the event loop. Reacting to events allows the user to interact with the application. Events are the things that can happen in a program, such as a

- mouse click,
- mouse movement,
- keyboard press,
- joystick action.

The following is an infinite loop which prints all events to the console:

```
while True:
    for event in pygame.event.get():
        print(event)
```

Try to move the mouse, click a mouse button, or type something on the keyboard. Every action you do produces an event which will be sent and printed on the console. This will look something like this:

```
<Event(4-MouseMotion {'pos': (173, 192), 'rel': (173, 192), 'buttons': (0, 0, 0),
↪'window': None})>
<Event(2-KeyDown {'unicode': 'a', 'key': 97, 'mod': 0, 'scancode': 0, 'window': None}
↪)>
<Event(3-KeyUp {'key': 97, 'mod': 0, 'scancode': 0, 'window': None})>
<Event(12-Quit {})>
```

As we are in an infite loop, it is impossible to quit this program from within the application. In order to quit the program, make the console the active window and type `ctrl-C`. This will write the following message to the console:

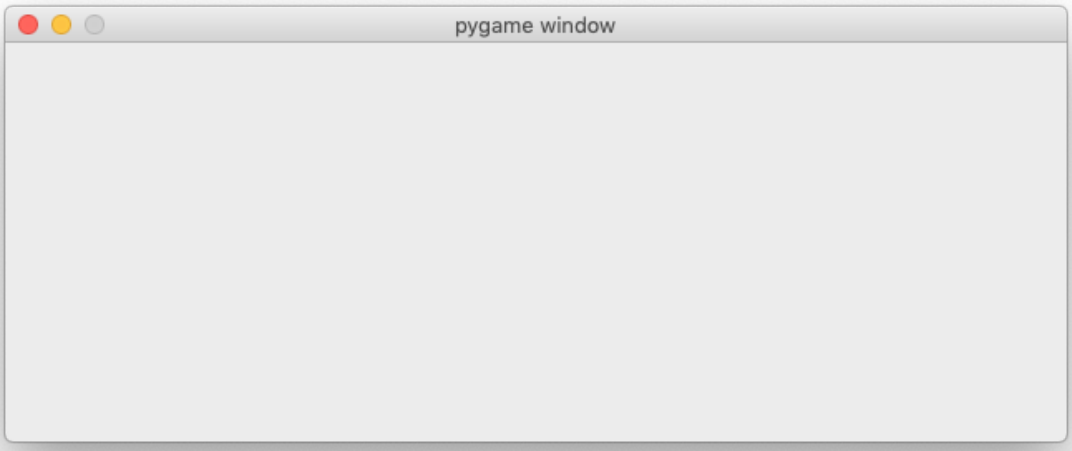
```
^CTraceback (most recent call last):
File "/Users/raphael/GitHub/pygame-tutorial/docs/tutorial1/intro1.py", line 7, in
↪<module>
    for event in pygame.event.get():
KeyboardInterrupt
```

1.3 Quit the event loop properly

In order to quit the application properly, from within the application, by using the window close button (QUIT event), we modify the event loop. First we introduce the boolean variable `running` and set it to `True`. Within the event loop we check for the QUIT event. If it occurs, we set `running` to `False`:

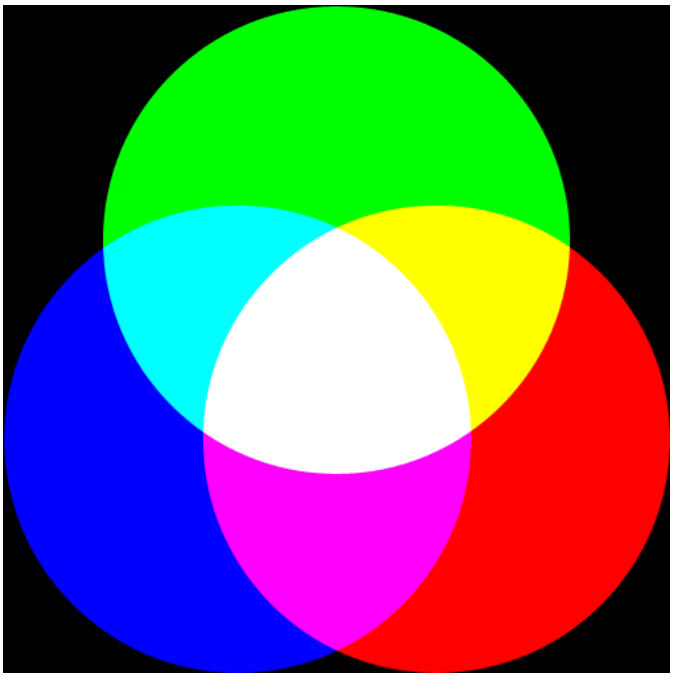
```
running = True
while running:
    for event in pygame.event.get():
        if event.type == pygame.QUIT:
            running = False

pygame.quit()
```

Once the event loop, we call the `pygame.quit()` function to end the application correctly.



1.4 Define colors

Colors are defined as tuples of the base colors red, green and blue. This is called the **RGB model**. Each base color is represented as a number between 0 (minimum) and 255 (maximum) which occupies 1 byte in memory. An RGB color is thus represented as a 3-byte value. Mixing two or more colors results in new colors. A total of 16 million different colors can be represented this way.



Let's define the base colors as tuples. Since these are constants, we are going to use capitals. At the beginning of the program we add:

```
BLACK = (0, 0, 0)
RED = (255, 0, 0)
GREEN = (0, 255, 0)
BLUE = (0, 0, 255)
```

Further we define the colors obtained by mixing two or more of the base colors:

```
YELLOW = (255, 255, 0)
CYAN = (0, 255, 255)
MAGENTA = (255, 0, 255)
GRAY = (127, 127, 127)
WHITE = (255, 255, 255)
```

Inside the event loop, at its end we add the following:

```
screen.fill(YELLOW)
pygame.display.update()
```

The method `fill(color)` fills the whole screen with the specified color. At this point nothing will be displayed. In order to show anything, the function `pygame.display.update()` must be called.

1.5 Switch the background color

At the beginning of the program we add a new veriable `background` and initialze it to gray:

```
background = GRAY
```

Within the event loop we are looking now for `KEYDONW` events. If found, we check if the R or G keys have been pressed and change the background color to red (R) and green (G). This is the code added in the event loop:

```
if event.type == pygame.KEYDOWN:
    if event.key == pygame.K_r:
        background = RED
```

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```
    elif event.key == pygame.K_g:
        background = GREEN
```

In the drawing section we use now the variable `background` representing the background color:

```
screen.fill(background)
pygame.display.update()
```

Test the program. Pressing the R and G keys allows you to switch the background color.

1.6 Import pygame.locals

The `pygame.locals` module contains some 280 constants used and defined by pygme. Placing this statement at the beginning of your programm imports them all:

```
import pygame
from pygame.locals import *
```

We find the key modifiers (alt, ctrl, cmd, etc.)

```
KMOD_ALT, KMOD_CAPS, KMOD_CTRL, KMOD_LALT,
KMOD_LCTRL, KMOD_LMETA, KMOD_LSHIFT, KMOD_META,
KMOD_MODE, KMOD_NONE, KMOD_NUM, KMOD_RALT, KMOD_RCTRL,
KMOD_RMETA, KMOD_RSHIFT, KMOD_SHIFT,
```

the number keys:

```
K_0, K_1, K_2, K_3, K_4, K_5, K_6, K_7, K_8, K_9,
```

the special character keys:

```
K_AMPERSAND, K_ASTERISK, K_AT, K_BACKQUOTE,
K_BACKSLASH, K_BACKSPACE, K_BREAK,
```

the function keys:

```
K_F1, K_F2, K_F3, K_F4, K_F5, K_F6, K_F7, K_F8,
K_F9, K_F10, K_F11, K_F12, K_F13, K_F14, K_F15
```

the letter keys of the alphabet:

```
K_a, K_b, K_c, K_d, K_e, K_f, K_g, K_h, K_i, K_j, K_k, K_l, K_m,
K_n, K_o, K_p, K_q, K_r, K_s, K_t, K_u, K_v, K_w, K_x, K_y, K_z,
```

Instead of writing `pygame.KEYDOWN` we can now just write `` `KEYDOWN ``.

1.7 Use a dictionary to decode keys

The easiest way to decode many keys, is to use a dictionary. Instead of defining many if-else cases, we just create a dictionary with the keyboard key entries. In this exemple we want to associate 8 different keys with 8 different background colors. At the beginning of the programm we define this key-color dictionary:

```
key_dict = {K_k:BLACK, K_r:RED, K_g:GREEN, K_b:BLUE,
    K_y:YELLOW, K_c:CYAN, K_m:MAGENTA, K_w:WHITE}

print(key_dict)
```

Printing the dictionary to the console gives this result:

```
{107: (0, 0, 0), 114: (255, 0, 0), 103: (0, 255, 0), 98: (0, 0, 255),
121: (255, 255, 0), 99: (0, 255, 255), 109: (255, 0, 255), 119: (255, 255, 255)}
```

The keys are presented here with their ASCII code. For exaple the ASCII code for `k` is 107. Colors are represented as tuples. The color black is represented as (0, 0, 0).

The event loop now becomes very simple. First we check if the event type is a KEYDOWN event. If yes, we check if the event key is in the dictionary. If yes, we look up the color which is associated with that key and set the background color to it:

```
if event.type == KEYDOWN:
    if event.key in key_dict:
        background = key_dict[event.key]
```

Try to press the 8 specified keys to change the background color.

1.8 Change the window caption

The fonction `pygame.display.set_caption(title)` allows to change the caption (title) of the application window. We can add this to the event loop:

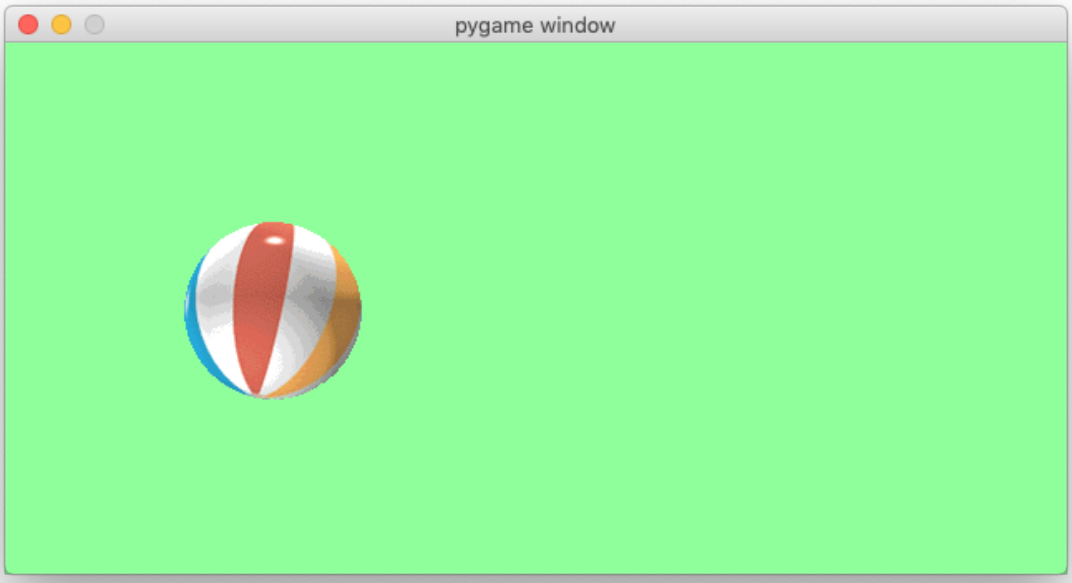
```
if event.key in key_dict:
    background = key_dict[event.key]

    caption = 'background color = ' + str(background)
    pygame.display.set_caption(caption)
```

This will display the RGB value of the current background color in the window caption.

1.9 Explore a simple ball game

To show what Pygame can do, here is a simple program that does a bouncing ball animation:

```
import pygame
from pygame.locals import *

width = 640
height = 320
speed = [2, 2]
GREEN = (150, 255, 150)
running = True

pygame.init()
screen = pygame.display.set_mode((width, height))
ball = pygame.image.load("ball.gif")
ballrect = ball.get_rect()

while running:
    for event in pygame.event.get():
        if event.type == QUIT:
            running = False

    ballrect = ballrect.move(speed)
    if ballrect.left < 0 or ballrect.right > width:
        speed[0] = -speed[0]
    if ballrect.top < 0 or ballrect.bottom > height:
        speed[1] = -speed[1]

    screen.fill(GREEN)
    screen.blit(ball, ballrect)
    pygame.display.flip()

pygame.quit()
```



`ball.gif`

Try to understand what the program does. Then try to modify it's parameters.

CHAPTER 2

Drawing graphics primitives

The `pygame.draw` module allows to draw simple shapes to a surface. This can be the screen surface or any Surface object such as an image or drawing:

- rectangle
- polygon
- circle
- ellipse

The functions have in common that they:

- take a **Surface** object as first argument
- take a color as second argument
- take a width parameter as last argument
- return a **Rect** object which bounds the changed area

the following format:

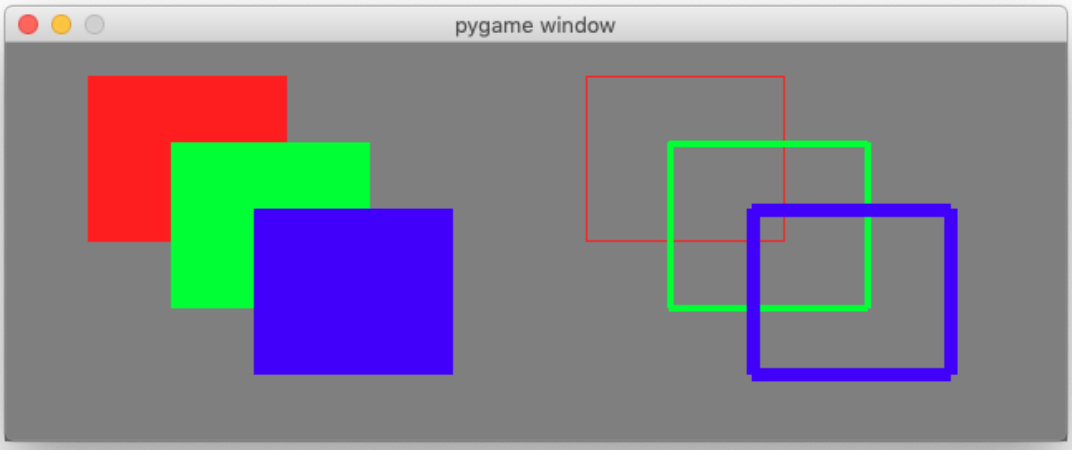
```
rect(Surface, color, Rect, width) -> Rect
polygon(Surface, color, pointlist, width) -> Rect
circle(Surface, color, center, radius, width) -> Rect
```

Most of the functions take a width argument. If the width is 0, the shape is filled.

2.1 Draw solid and outlined rectangles

The following draws first the background color and then adds three overlapping solid rectangles and next to it three oulined overlapping rectangles with increasing line width:

```
screen.fill(background)
pygame.draw.rect(screen, RED, (50, 20, 120, 100))
pygame.draw.rect(screen, GREEN, (100, 60, 120, 100))
pygame.draw.rect(screen, BLUE, (150, 100, 120, 100))

pygame.draw.rect(screen, RED, (350, 20, 120, 100), 1)
pygame.draw.rect(screen, GREEN, (400, 60, 120, 100), 4)
pygame.draw.rect(screen, BLUE, (450, 100, 120, 100), 8)
```

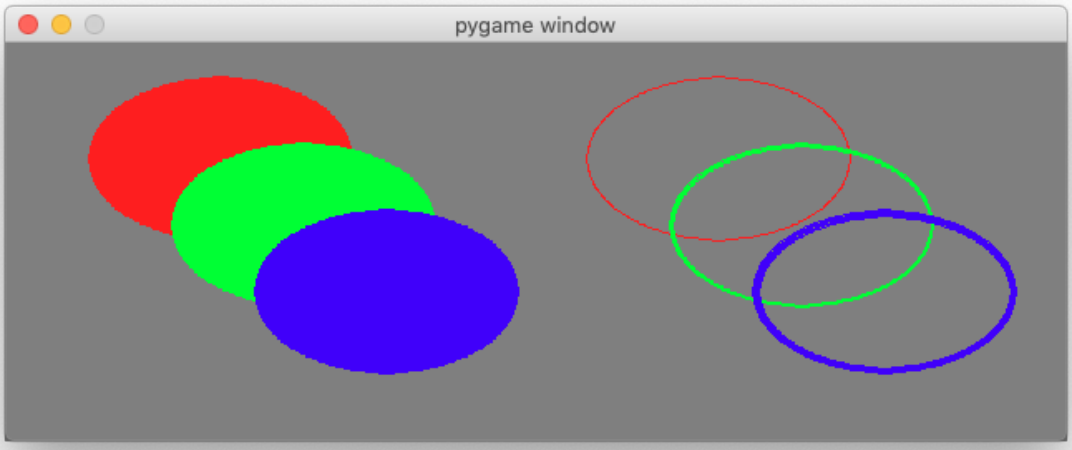


Try to modifiy the parameters and play with the drawing function.

2.2 Draw solid and outlined ellipses

The following code draws first the background color and then adds three overlapping solid ellipses and next to it three oulined overlapping ellipses with increasing line width:

```
screen.fill(background)
pygame.draw.ellipse(screen, RED, (50, 20, 160, 100))
pygame.draw.ellipse(screen, GREEN, (100, 60, 160, 100))
pygame.draw.ellipse(screen, BLUE, (150, 100, 160, 100))

pygame.draw.ellipse(screen, RED, (350, 20, 160, 100), 1)
pygame.draw.ellipse(screen, GREEN, (400, 60, 160, 100), 4)
pygame.draw.ellipse(screen, BLUE, (450, 100, 160, 100), 8)

pygame.display.update()
```



2.3 Detect the mouse

Pressing the mouse buttons produces MOUSEBUTTONDOWN and MOUSEBUTTONUP events. The flollowing code in the event loop detects them and writes the event to the console:

```
for event in pygame.event.get():
    if event.type == QUIT:
        running = False
    elif event.type == MOUSEBUTTONDOWN:
        print(event)
    elif event.type == MOUSEBUTTONUP:
        print(event)
```

Pressing the mouse buttons produces this kind of events:

```
<Event(5-MouseButtonDown {'pos': (123, 88), 'button': 1, 'window': None})>
<Event(6-MouseButtonUp {'pos': (402, 128), 'button': 1, 'window': None})>
<Event(5-MouseButtonDown {'pos': (402, 128), 'button': 3, 'window': None})>
<Event(6-MouseButtonUp {'pos': (189, 62), 'button': 3, 'window': None})>
```

Just moving the mouse produces a MOUSEMOTION event. The following code detects them an writes the event to the console:

```
elif event.type == MOUSEMOTION:
    print(event)
```

Moving the mosue produces this kind of event:

```
<Event(4-MouseMotion {'pos': (537, 195), 'rel': (-1, 0), 'buttons': (0, 0, 0), 'window
↪': None})>
<Event(4-MouseMotion {'pos': (527, 189), 'rel': (-10, -6), 'buttons': (0, 0, 0),
↪'window': None})>
<Event(4-MouseMotion {'pos': (508, 180), 'rel': (-19, -9), 'buttons': (0, 0, 0),
↪'window': None})>
```

2.4 Draw a rectangle with the mouse

We can use this three events to draw a rectangle on the screen. We define the rectangle by its diagonal start and end point. We also need a flag which indicates if the mouse button is down and if we are drawing:

```
start = (0, 0)
size = (0, 0)
drawing = False
```

When the mouse button is pressed, we set start and end to the current mouse position and indciate with the flag that the drawing mode has started:

```
elif event.type == MOUSEBUTTONDOWN:
    start = event.pos
    size = 0, 0
    drawing = True
```

When the mouse button is released, we set the end point and indicate with the flag that the drawing mode has ended:

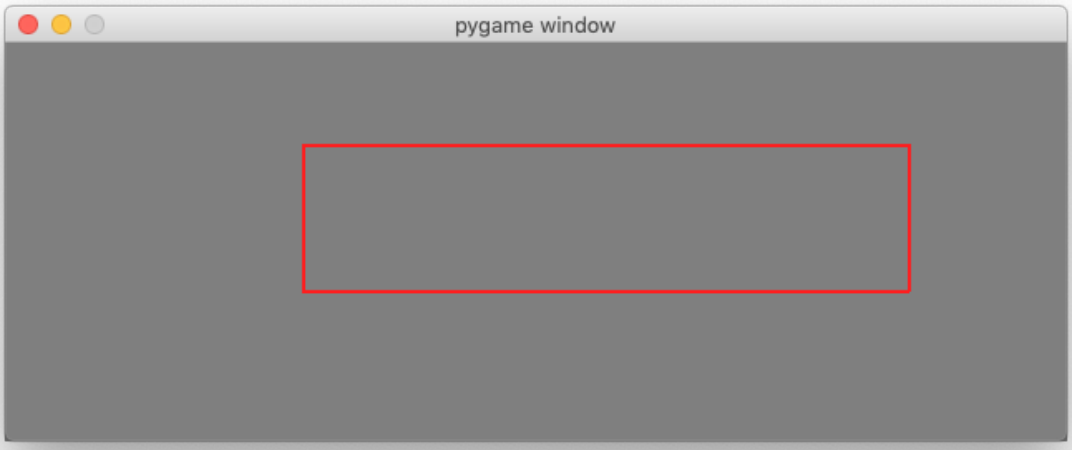
```
elif event.type == MOUSEBUTTONUP:
    end = event.pos
    size = end[0] - start[0], end[1] - start[1]
    drawing = False
```

When the mouse is moving we have also have to check if we are in drawing mode. If yes, we set the end position to the current mouse position:

```
elif event.type == MOUSEMOTION and drawing:
    end = event.pos
    size = end[0] - start[0], end[1] - start[1]
```

Finally we draw the rectangle to the screen. First we fill in the background color. Then we calculate the size of the rectangle. Finally we draw it, and at the very last we update the screen:

```
screen.fill(GRAY)
pygame.draw.rect(screen, RED, (start, size), 2)
pygame.display.update()
```



2.5 Draw multiple shapes

To draw multiple shapes, we need to place them into a list. Besides variables for `start`, `end` and `drawing` we add a rectangle list:

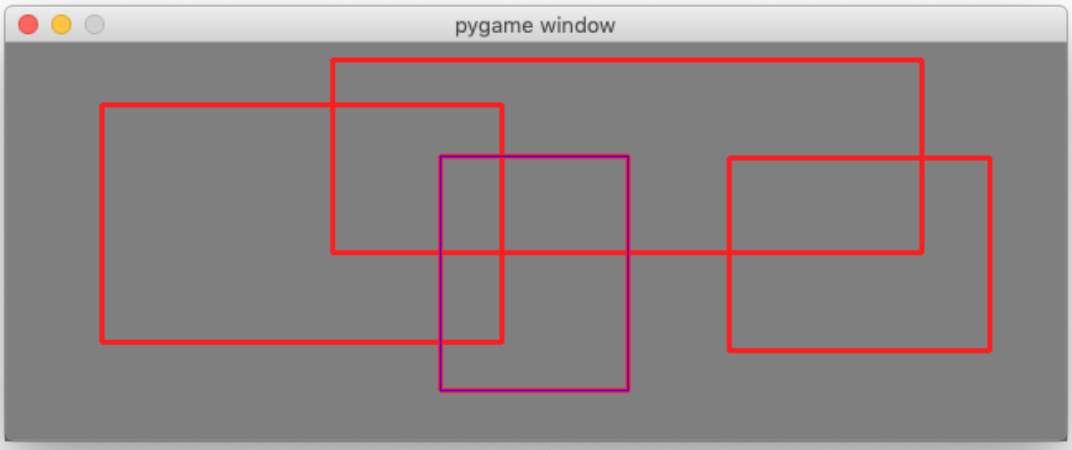
```
start = (0, 0)
size = (0, 0)
drawing = False
rect_list = []
```

When drawing of an object (rectangle, circle, etc.) is done, as indicated by a MOUSEBUTTONUP event, we create a rectangle and append it to the rectangle list:

```
elif event.type == MOUSEBUTTONUP:
    end = event.pos
    size = end[0]-start[0], end[1]-start[1]
    rect = pygame.Rect(start, size)
    rect_list.append(rect)
    drawing = False
```

In the drawing code, we first fill the background color, then iterate through the rectagle list to draw the objects (red, thickness=3), and finally we draw the current rectangle which is in the process of being drawn (blue, thickness=1):

```
screen.fill(GRAY)
for rect in rect_list:
    pygame.draw.rect(screen, RED, rect, 3)
pygame.draw.rect(screen, BLUE, (start, size), 1)
pygame.display.update()
```



Here is the complete file:

```
"""Place multiple rectangles with the mouse."""

import pygame
from pygame.locals import *

RED = (255, 0, 0)
BLUE = (0, 0, 255)
GRAY = (127, 127, 127)

pygame.init()
screen = pygame.display.set_mode((640, 240))

start = (0, 0)
size = (0, 0)
drawing = False
rect_list = []

running = True

while running:
    for event in pygame.event.get():
        if event.type == QUIT:
            running = False

        elif event.type == MOUSEBUTTONDOWN:
            start = event.pos
            size = 0, 0
            drawing = True

        elif event.type == MOUSEBUTTONUP:
            end = event.pos
            size = end[0]-start[0], end[1]-start[1]
            rect = pygame.Rect(start, size)
            rect_list.append(rect)
```

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```
            drawing = False

        elif event.type == MOUSEMOTION and drawing:
            end = event.pos
            size = end[0]-start[0], end[1]-start[1]

    screen.fill(GRAY)
    for rect in rect_list:
        pygame.draw.rect(screen, RED, rect, 3)
    pygame.draw.rect(screen, BLUE, (start, size), 1)
    pygame.display.update()

pygame.quit()
```

2.6 Draw a pologyon line with the mouse

To draw a polygon line we need to add the points to a list of points. First we define an empty point list and a drawing flag:

```
drawing = False
points = []
```

At the MOUSEBUTTONDOWN event we add the current point to the list and set the `drawing` flag to True:

```
elif event.type == MOUSEBUTTONDOWN:
    points.append(event.pos)
    drawing = True
```

At the MOUSEBUTTONUP event we deactivate the `drawing` flag:

```
elif event.type == MOUSEBUTTONUP:
    drawing = False
```

At the MOUSEMOTION event we move the last point in the polygon list if the drawing flag is set:

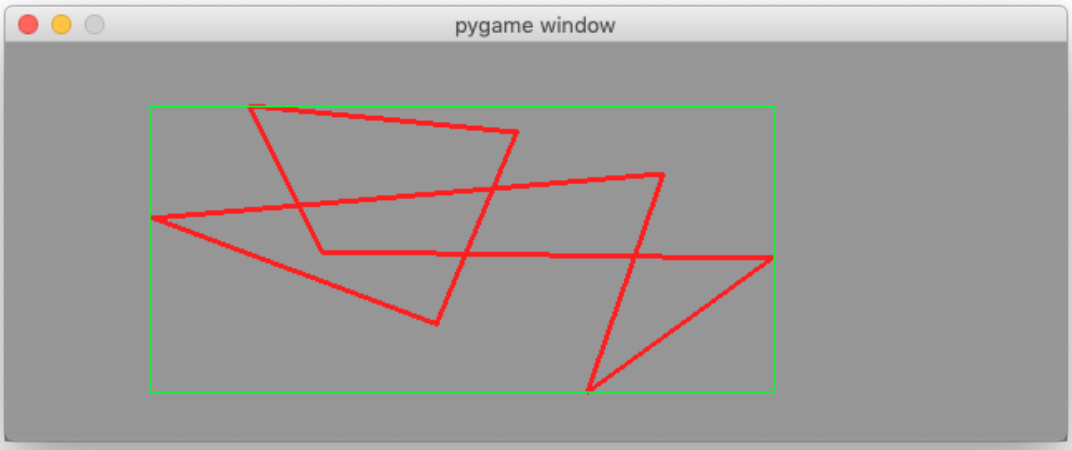
```
elif event.type == MOUSEMOTION and drawing:
    points[-1] = event.pos
```

If there are more than 2 points in the point list we draw a polygon line. Each `pygame.draw` function returns a `Rect` of the bounding rectangle. We display this bounding rectangle in green:

```
screen.fill(GRAY)
if len(points)>1:
    rect = pygame.draw.lines(screen, RED, True, points, 3)
    pygame.draw.rect(screen, GREEN, rect, 1)
pygame.display.update()
```

Pressing the ESCAPE key will remove the last point in the list:

```
elif event.type == KEYDOWN:
    if event.key == K_ESCAPE:
        if len(points) > 0:
            points.pop()
```



Here is the complete file:

```
"""Place a polygone line with the clicks of the mouse."""

import pygame
from pygame.locals import *

RED = (255, 0, 0)
GREEN = (0, 255, 0)
GRAY = (150, 150, 150)

pygame.init()
screen = pygame.display.set_mode((640, 240))

drawing = False
points = []
running = True

while running:
    for event in pygame.event.get():
        if event.type == QUIT:
            running = False

        elif event.type == KEYDOWN:
            if event.key == K_ESCAPE:
                if len(points) > 0:
                    points.pop()

        elif event.type == MOUSEBUTTONDOWN:
            points.append(event.pos)
            drawing = True

        elif event.type == MOUSEBUTTONUP:
            drawing = False

        elif event.type == MOUSEMOTION and drawing:
```

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```
            points[-1] = event.pos

    screen.fill(GRAY)
    if len(points)>1:
        rect = pygame.draw.lines(screen, RED, True, points, 3)
        pygame.draw.rect(screen, GREEN, rect, 1)
    pygame.display.update()

pygame.quit()
```

CHAPTER 3

Working with images

3.1 Load an image

The `pyagme.image` module provides methods for loading and saving images. The method `load()` loads an image from the file system and returns a Surface object. The method `convert()` optimizes the image format and makes drawing faster:

```
img = pygame.image.load('bird.png')
img.convert()
```

Download the image `bird.png` to the same folder where your program resides:

`bird.png`

The method `get_rect()` returns a Rect object from an image. At this point only the size is set and position is placed at (0, 0). We set the center of the Rect to the center of the screen:

```
rect = img.get_rect()
rect.center = w//2, h//2
```

To recapitulate, we are working with 3 objects:

- **screen** is the Surface object representing the application window
- **img** is the Surface object of the image to display
- **rect** is the Rect object which is the bounding rectangle of the image

To display the image we fill the screen with a background color (GRAY). Then we blit the image, draw a red rectangle around it and finally update the screen:

```
screen.fill(GRAY)
screen.blit(img, rect)
pygame.draw.rect(screen, RED, rect, 1)
pygame.display.update()
```

3.2 Move the image with the mouse

At the beginning of the programm we set a boolean variable `moving` to False. Only when the mouse button is pressed, and when the mouse position is within the image (collidepoint) we set it to True:

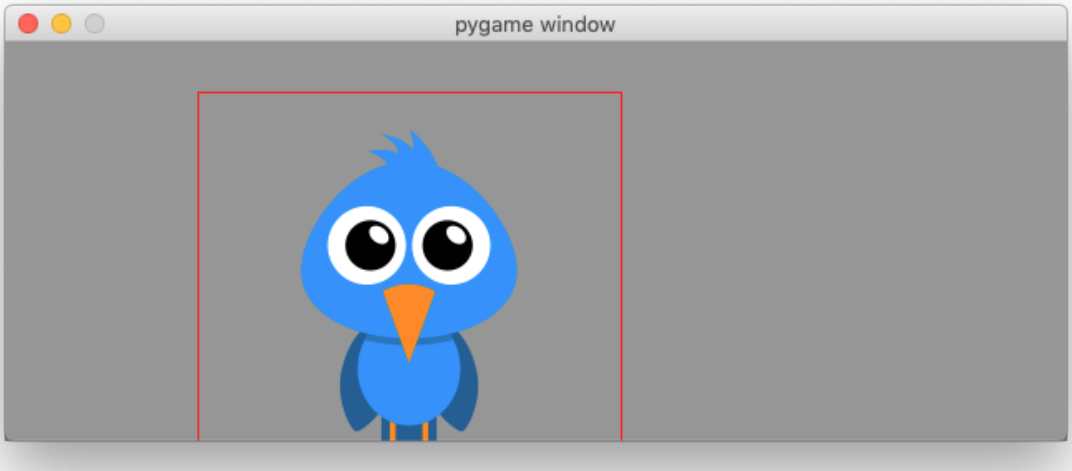
```
elif event.type == MOUSEBUTTONDOWN:
    if rect.collidepoint(event.pos):
        moving = True
```

When the mouse button is released, we set it to False again:

```
elif event.type == MOUSEBUTTONUP:
    moving = False
```

When the mouse moves, and the flag `moving` is True, then we move the image by the amount of relative movement (event.rel):

```
elif event.type == MOUSEMOTION and moving:
    rect.move_ip(event.rel)
```



This is the whole code:

```
"""Move an image with the mouse."""

import pygame
from pygame.locals import *

RED = (255, 0, 0)
GRAY = (150, 150, 150)

pygame.init()
w, h = 640, 240
screen = pygame.display.set_mode((w, h))
running = True
```

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```
img = pygame.image.load('bird.png')
img.convert()
rect = img.get_rect()
rect.center = w//2, h//2
moving = False

while running:
    for event in pygame.event.get():
        if event.type == QUIT:
            running = False

        elif event.type == MOUSEBUTTONDOWN:
            if rect.collidepoint(event.pos):
                moving = True

        elif event.type == MOUSEBUTTONUP:
            moving = False

        elif event.type == MOUSEMOTION and moving:
            rect.move_ip(event.rel)

    screen.fill(GRAY)
    screen.blit(img, rect)
    pygame.draw.rect(screen, RED, rect, 1)
    pygame.display.update()

pygame.quit()
```

3.3 Rotate and Scale the image

The `pygame.transform` module provides methods for **scaling, rotating and flipping** images. As we are going to modify the image **img** we keep the original image in a variable called **img0**:

```
img0 = pygame.image.load(path)
img0.convert()
```

In order to show the image rectangle, we add a green border to the original image:

```
rect0 = img0.get_rect()
pygame.draw.rect(img0, GREEN, rect0, 1)
```

Then we place the place the image in the center of the screen:

```
center = w//2, h//2
img = img0
rect = img.get_rect()
rect.center = center
```

First we define the global variables **scale** and **angle**:

```
angle = 0
scale = 1
```

We use the R key to increment rotation by 10 degrees and (decrement if the SHIFT key is pressed). The function

`rotozoom()` allows to combine rotation and scaling. We always transform the orignial image (img0). Repeated rotation or scaling of an image would degrade its quality:

```
if event.type == KEYDOWN:
    if event.key == K_r:
        if event.mod & KMOD_SHIFT:
            angle -= 10
        else:
            angle += 10
        img = pygame.transform.rotozoom(img0, angle, scale)
```

We use the S key to increment the scale by 10% (decrease if the SHIFT key is pressed):

```
elif event.key == K_s:
        if event.mod & KMOD_SHIFT:
            scale /= 1.1
        else:
            scale *= 1.1
        img = pygame.transform.rotozoom(img0, angle, scale)
```

As the image is transformed the bounding rectangle changes size. It must be recalulated and placed at the center again:

```
rect = img.get_rect()
rect.center = center
```

3.4 Reset the image to the original

We use the O key to reset the image to its original state:

```
elif event.key == K_o:
    img = img0
    angle = 0
    scale = 1
```

3.5 Flip the image

We use the H key to flip the image horizontally:

```
elif event.key == K_h:
    img = pygame.transform.flip(img, True, False)
```

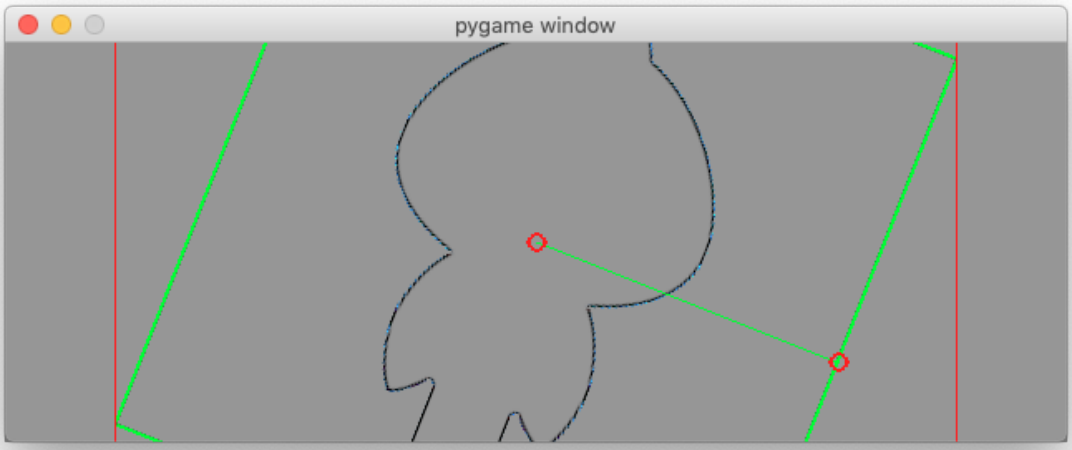
and the V key to flip the image vertically:

```
elif event.key == K_v:
    img = pygame.transform.flip(img, False, True)
```

3.6 Detect edges with the Laplacian

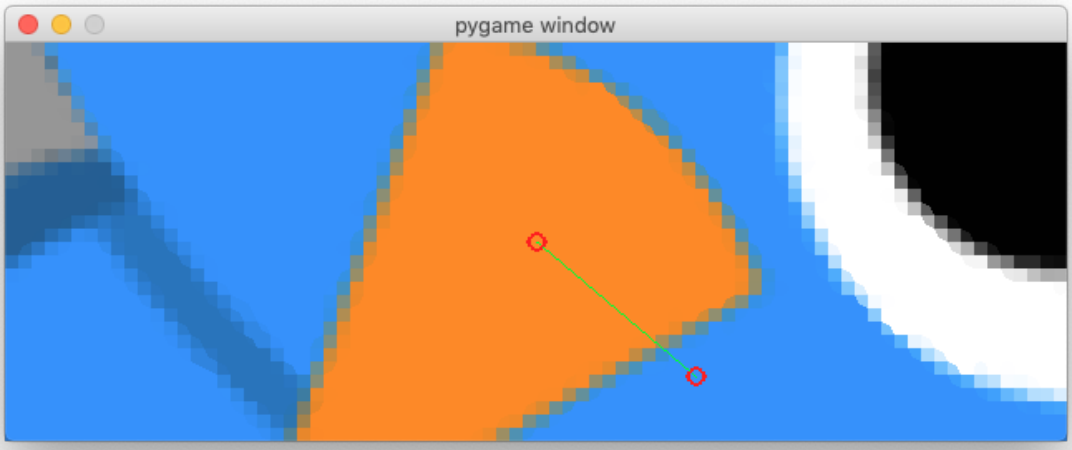
The fonction `laplacien(img)` allows to detect the outline of the image:

```
elif event.key == K_l:
    img = pygame.transform.laplacian(img)
```



The fonction `scale2x(img)` doubles the size of a pixel:

```
elif event.key == K_2:
    img = pygame.transform.scale2x(img)
```



3.7 Transform the image with the mouse

In this section we show how to use the mouse to scale and rotate an image. At the beginning we import the `math` module:

```
import math
```

At the beginning we store the initial mouse position:

```
mouse = pygame.mouse.get_pos()
```

When the mouse moves we update the mouse position `mouse` and calculate the **x, y** coordinates from the center of the image. We also calculate the center-mouse distance **d**

```
elif event.type == MOUSEMOTION:
    mouse = event.pos
    x = mouse[0] - center[0]
    y = mouse[1] - center[1]
    d = math.sqrt(x ** 2 + y ** 2)
```

The `atan2(y, x)` math function allows to find the rotation angle. We need to transform radians in degrees. From the distance mouse-center we calculate the scale argument:

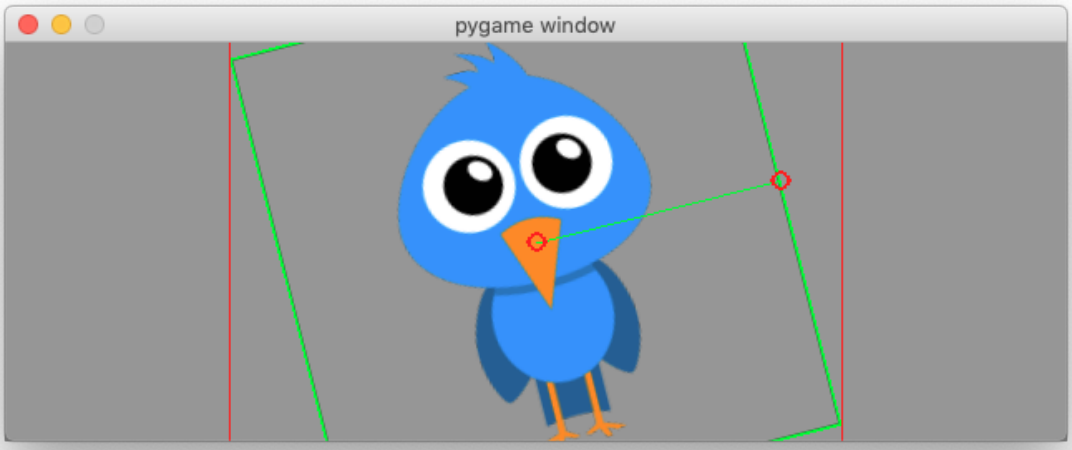
```
angle = math.degrees(-math.atan2(y, x))
scale = abs(5 * d / w)
img = pygame.transform.rotozoom(img0, angle, scale)
rect = img.get_rect()
rect.center = center
```

To finally draw the transformed image we first fille the whole screen background (GRAY), blit the transformed image, surround it with a red rectangle.

In order to give visual feedback for the mouse action when transforming an image, we

- draw a green line between the center of the image and the mouse position,
- place two circles on the center and on the mouse position:

```
screen.fill(GRAY)
screen.blit(img, rect)
pygame.draw.rect(screen, RED, rect, 1)
pygame.draw.line(screen, GREEN, center, mouse, 1)
pygame.draw.circle(screen, RED, center, 6, 1)
pygame.draw.circle(screen, RED, mouse, 6, 1)
pygame.display.update()
```



Here is the full code.

```
"""Rotate, scale and flip an image."""

import pygame
import math, sys, os
from pygame.locals import *

RED = (255, 0, 0)
GREEN = (0, 255, 0)
GRAY = (150, 150, 150)

pygame.init()
w, h = 640, 240
screen = pygame.display.set_mode((w, h))
running = True

module = sys.modules['__main__']
path, name = os.path.split(module.__file__)
path = os.path.join(path, 'bird.png')

img0 = pygame.image.load(path)
img0.convert()

# draw a green border around img0
rect0 = img0.get_rect()
pygame.draw.rect(img0, GREEN, rect0, 1)

center = w//2, h//2
img = img0
rect = img.get_rect()
rect.center = center

angle = 0
scale = 1
```

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```
mouse = pygame.mouse.get_pos()

while running:
    for event in pygame.event.get():
        if event.type == QUIT:
            running = False

        if event.type == KEYDOWN:
            if event.key == K_r:
                if event.mod & KMOD_SHIFT:
                    angle -= 10
                else:
                    angle += 10
                img = pygame.transform.rotozoom(img0, angle, scale)

            elif event.key == K_s:
                if event.mod & KMOD_SHIFT:
                    scale /= 1.1
                else:
                    scale *= 1.1
                img = pygame.transform.rotozoom(img0, angle, scale)

            elif event.key == K_o:
                img = img0
                angle = 0
                scale = 1

            elif event.key == K_h:
                img = pygame.transform.flip(img, True, False)

            elif event.key == K_v:
                img = pygame.transform.flip(img, False, True)

            elif event.key == K_l:
                img = pygame.transform.laplacian(img)

            elif event.key == K_2:
                img = pygame.transform.scale2x(img)

            rect = img.get_rect()
            rect.center = center

        elif event.type == MOUSEMOTION:
            mouse = event.pos
            x = mouse[0] - center[0]
            y = mouse[1] - center[1]
            d = math.sqrt(x ** 2 + y ** 2)

            angle = math.degrees(-math.atan2(y, x))
            scale = abs(5 * d / w)
            img = pygame.transform.rotozoom(img0, angle, scale)
            rect = img.get_rect()
            rect.center = center

    screen.fill(GRAY)
    screen.blit(img, rect)
    pygame.draw.rect(screen, RED, rect, 1)
```

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```
    pygame.draw.line(screen, GREEN, center, mouse, 1)
    pygame.draw.circle(screen, RED, center, 6, 1)
    pygame.draw.circle(screen, RED, mouse, 6, 1)
    pygame.display.update()

pygame.quit()
```

CHAPTER 4

Work with text

In pygame, text cannot be written directly to the screen. The first step is to create a `Font` object with a given font size. The second step is to render the text into an image with a given color. The third step is to blit the image to the screen. These are the steps:

```
font = pygame.font.SysFont(None, 24)
img = font.render('hello', True, BLUE)
screen.blit(img, (20, 20))
```

Once the font is created, its size cannot be changed. A `Font` object is used to create a `Surface` object from a string. Pygame does not provide a direct way to write text onto a `Surface` object. The method `render()` must be used to create a Surface object from the text, which then can be blit to the screen. The method `render()` can only render single lines. A newline character is not rendered.

4.1 Initialize a font

Initializing the font can take a few seconds. On a MacBook Air the the creation of a system Font object:

```
t0 = time.time()
font = pygame.font.SysFont(None, 48)
print('time needed for Font creation :', time.time()-t0)
```

took more then 8 seconds:

```
time needed for Font creation : 8.230187892913818
```

The function `get_fonts()` returns a list of all installed fonts. The following code checks what fonts are on your system and how many, and prints them to the console:

```
fonts = pygame.font.get_fonts()
print(len(fonts))
for f in fonts:
    print(f)
```

You will get something like this:

```
344
bigcaslonttf
silomttf
sfnsdisplayblackitalicotf
chalkdusterttf
...
```

4.2 Render the text

The font object can render a given text into an image. In the example below, we place a blue bounding rectangle around that text image:

```
img = font.render(sysfont, True, RED)
rect = img.get_rect()
pygame.draw.rect(img, BLUE, rect, 1)
```

We then create two more fonts, *Chalkduster* and *Didot* at a size of 72 points. We render a text with both fonts:

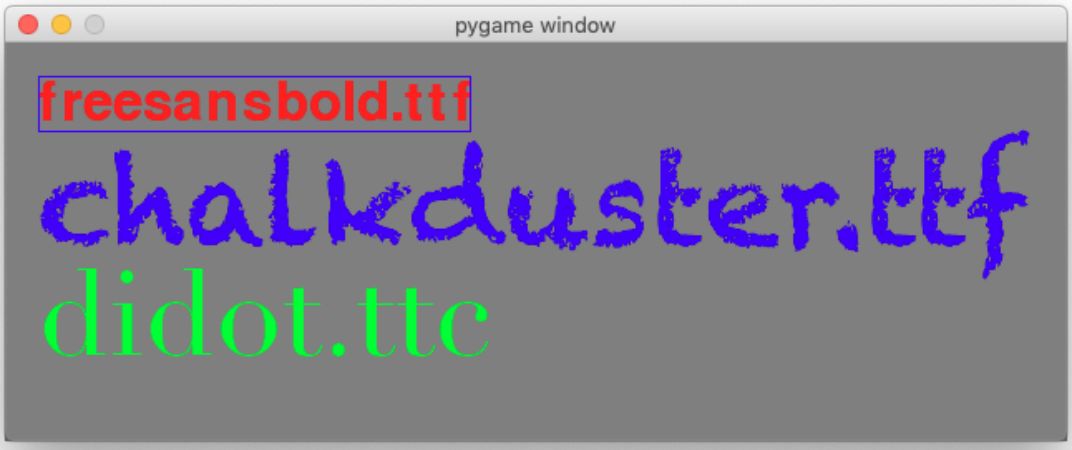
```
font1 = pygame.font.SysFont('chalkduster.ttf', 72)
img1 = font1.render('chalkduster.ttf', True, BLUE)

font2 = pygame.font.SysFont('didot.ttc', 72)
img2 = font2.render('didot.ttc', True, GREEN)
```

Finally the text images are blit to the screen like regular images:

```
screen.fill(background)
screen.blit(img, (20, 20))
screen.blit(img1, (20, 50))
screen.blit(img2, (20, 120))
pygame.display.update()
```

This is the result:



Here is the full code.

```
"""Draw text to the screen."""
import pygame
from pygame.locals import *
import time

BLACK = (0, 0, 0)
RED = (255, 0, 0)
GREEN = (0, 255, 0)
BLUE = (0, 0, 255)
GRAY = (200, 200, 200)

pygame.init()
screen = pygame.display.set_mode((640, 240))

sysfont = pygame.font.get_default_font()
print('system font :', sysfont)

t0 = time.time()
font = pygame.font.SysFont(None, 48)
print('time needed for Font creation :', time.time()-t0)

img = font.render(sysfont, True, RED)
rect = img.get_rect()
pygame.draw.rect(img, BLUE, rect, 1)

font1 = pygame.font.SysFont('chalkduster.ttf', 72)
img1 = font1.render('chalkduster.ttf', True, BLUE)

font2 = pygame.font.SysFont('didot.ttc', 72)
img2 = font2.render('didot.ttc', True, GREEN)

fonts = pygame.font.get_fonts()
print(len(fonts))
for i in range(7):
```

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```
    print(fonts[i])

running = True
background = GRAY
while running:
    for event in pygame.event.get():
        if event.type == QUIT:
            running = False

    screen.fill(background)
    screen.blit(img, (20, 20))
    screen.blit(img1, (20, 50))
    screen.blit(img2, (20, 120))
    pygame.display.update()

pygame.quit()
```

4.3 Edit text with the keybord

The keyboard event can be used to edit a text. First we create a text which we save in a string variable `text` and which we render to an image:

```
text = 'this text is editable'
font = pygame.font.SysFont(None, 48)
img = font.render(text, True, RED)
```

Then we define the bounding rectangle and furthermore a cursor rectangle which is juxtaposed to the text bounding rectangle:

```
rect = img.get_rect()
rect.topleft = (20, 20)
cursor = Rect(rect.topright, (3, rect.height))
```

Inside the event loop we watch out for KEYDOWN events. If the key press is a BACKSPACE and the lenght of the string is larger than 0, then we remove the last character, else we append the new character to the text variable:

```
if event.type == KEYDOWN:
    if event.key == K_BACKSPACE:
        if len(text)>0:
            text = text[:-1]
    else:
        text += event.unicode
```

Then we render the modified text, update the bounding rectangle, and place the cursor box at the end of the updated bounding rectangle:

```
img = font.render(text, True, RED)
rect.size=img.get_size()
cursor.topleft = rect.topright
```

4.4 Add a blinking cursor

In order to make the cursor more visible, we let it blink every 0.5 seconds. We do this using the time.time() floating point value:

```
screen.fill(background)
screen.blit(img, rect)
if time.time() % 1 > 0.5:
    pygame.draw.rect(screen, RED, cursor)
pygame.display.update()
```

This is the result:

Here is the full code.

```
"""Edit text with the keyboard."""
import pygame
from pygame.locals import *
import time

BLACK = (0, 0, 0)
RED = (255, 0, 0)
GRAY = (200, 200, 200)

pygame.init()
screen = pygame.display.set_mode((640, 240))

text = 'this text is editable'
font = pygame.font.SysFont(None, 48)
img = font.render(text, True, RED)

rect = img.get_rect()
rect.topleft = (20, 20)
cursor = Rect(rect.topright, (3, rect.height))

running = True
background = GRAY
```

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```
while running:
    for event in pygame.event.get():
        if event.type == QUIT:
            running = False

        if event.type == KEYDOWN:
            if event.key == K_BACKSPACE:
                if len(text)>0:
                    text = text[:-1]
            else:
                text += event.unicode
            img = font.render(text, True, RED)
            rect.size=img.get_size()
            cursor.topleft = rect.topright

    screen.fill(background)
    screen.blit(img, rect)
    if time.time() % 1 > 0.5:
        pygame.draw.rect(screen, RED, cursor)
    pygame.display.update()

pygame.quit()
```

CHAPTER 5

Making apps with Pygame

In this section we are going to create applications and games with Pygame. From here on we will be using an object-oriented programming (OOP) approach.

Pygame only allows to create one single window. Different from other applications, those based on Pygame cannot have multiple windows. If for example dialog window is needed, it must be displayed within the main window.

Within an application we provide multples scenes (environments, rooms, or levels). Each scene contains different objects such as:

- text
- sprites (images)
- GUI elements (buttons, menus)
- shapes (rectangles, circles)

5.1 Create the App class

The basis for a game or application is the `App` class. The first thing to do is to import the `pygame` module, as well as a series of useful constants:

```
import pygame
from pygame.locals import *
```

Then we create define the App class which initializes Pygame and opens a the app window:

```
class App:
    """Create a single-window app with multiple scenes."""

    def __init__(self):
        """Initialize pygame and the application."""
        pygame.init()
        flags = RESIZABLE
```

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```
        App.screen = pygame.display.set_mode((640, 240), flags)

        App.running = True
```

Further we have to define the main event loop:

```
def run(self):
    """Run the main event loop."""
    while App.running:
        for event in pygame.event.get():
            if event.type == QUIT:
                App.running = False
    pygame.quit()
```

At the end of the module we run a demo, if the programm is run directly and not imported as a module:

```
if __name__ == '__main__':
    App().run()
```

5.2 Add the Text class

Now we add some text to the screen. We create a Text class from which we can instantiate text objects:

```
class Text:
    """Create a text object."""

    def __init__(self, text, pos, **options):
        self.text = text
        self.pos = pos

        self.fontname = None
        self.fontsize = 72
        self.fontcolor = Color('black')
        self.set_font()
        self.render()
```

The `Font` object needs to be created initially and everytime the font name or the font size changes:

```
def set_font(self):
    """Set the font from its name and size."""
    self.font = pygame.font.Font(self.fontname, self.fontsize)
```

The text needs to be rendered into a surface object, an image. This needs to be done only once, or whenever the text changes:

```
def render(self):
    """Render the text into an image."""
    self.img = self.font.render(self.text, True, self.fontcolor)
    self.rect = self.img.get_rect()
    self.rect.topleft = self.pos
```

Drawing the text means blitting it to the application screen:

```
def draw(self):
    """Draw the text image to the screen."""
    App.screen.blit(self.img, self.rect)
```

This is the result:

Here is the complete code:

```
import pygame
from pygame.locals import *

class Text:
    """Create a text object."""

    def __init__(self, text, pos, **options):
        self.text = text
        self.pos = pos

        self.fontname = None
        self.fontsize = 72
        self.fontcolor = Color('black')
        self.set_font()
        self.render()

    def set_font(self):
        """Set the Font object from name and size."""
        self.font = pygame.font.Font(self.fontname, self.fontsize)

    def render(self):
        """Render the text into an image."""
        self.img = self.font.render(self.text, True, self.fontcolor)
        self.rect = self.img.get_rect()
        self.rect.topleft = self.pos

    def draw(self):
        """Draw the text image to the screen."""
```

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```
        App.screen.blit(self.img, self.rect)

class App:
    """Create a single-window app with multiple scenes."""

    def __init__(self):
        """Initialize pygame and the application."""
        pygame.init()
        flags = RESIZABLE
        App.screen = pygame.display.set_mode((640, 240), flags)
        App.t = Text('Pygame App', pos=(20, 20))

        App.running = True

    def run(self):
        """Run the main event loop."""
        while App.running:
            for event in pygame.event.get():
                if event.type == QUIT:
                    App.running = False

            App.screen.fill(Color('gray'))
            App.t.draw()
            pygame.display.update()

        pygame.quit()

if __name__ == '__main__':
    App().run()
```

5.3 Shortcut keys

Key presses (called shortcuts) can be used to interact with the application and run commands. We can add the following code inside the event loop to intercept the S key and print a message:

```
if event.type == KEYDOWN:
    if event.key == K_s:
        print('Key press S')
```

If the application has many shortcuts, the keys alone may not be enoufht and modifier keys (cmd, ctrl, alt, shift) can be used to increase the number of combinations. The easiest way to represent these shortcuts is under the form of a dictionary, where the key/mod tuples are associated with a command strings. The dictionary has this shape:

```
self.shortcuts = {
    (K_x, KMOD_LMETA): 'print("cmd+X")',
    (K_x, KMOD_LALT): 'print("alt+X")',
    (K_x, KMOD_LCTRL): 'print("ctrl+X")',
    (K_x, KMOD_LMETA + KMOD_LSHIFT): 'print("cmd+shift+X")',
    (K_x, KMOD_LMETA + KMOD_LALT): 'print("cmd+alt+X")',
    (K_x, KMOD_LMETA + KMOD_LALT + KMOD_LSHIFT): 'print("cmd+alt+shift+X")',
}
```

Inside the event loop we detect keydown events and call the key handler:

```
if event.type == KEYDOWN:
    self.do_shortcut(event)
```

The `do_shortcut()` method looks up the shortcut and executes the command string:

```
def do_shortcut(self, event):
    """Find the the key/mod combination in the dictionary and execute the cmd."""
    k = event.key
    m = event.mod
    if (k, m) in self.shortcuts:
        exec(self.shortcuts[k, m])
```

This is the result on the console when pressing different key+modifier combinations:

```
cmd+X
alt+X
ctrl+X
cmd+shift+X
cmd+alt+X
cmd+alt+shift+X
```

5.4 Fullscreen, resizable and noframe mode

Pygame allows a window to be displayed in 3 different modes:

- fullscreen mode
- resizable (a resize edge is displayed)
- noframe mode (without a window title bar)

Inside the `App` class `__init__()` method we first define the screen size and the display mode flags, and then create the `screen` surface:

```
self.flags = RESIZABLE
self.rect = Rect(0, 0, 640, 240)
App.screen = pygame.display.set_mode(self.rect.size, self.flags)
```

In order to toggle (turn on and off) the three display modes we add these entries to the `shortcuts` dictionary:

```
(K_f, KMOD_LMETA): 'self.toggle_fullscreen()',
(K_r, KMOD_LMETA): 'self.toggle_resizable()',
(K_g, KMOD_LMETA): 'self.toggle_frame()',
```

Inside the `App` class we define three methods to toggle the corresponding mode flag, by using the bit-wise XOR operator (^=):

```
def toggle_fullscreen(self):
    """Toggle between full screen and windowed screen."""
    self.flags ^= FULLSCREEN
    pygame.display.set_mode((0, 0), self.flags)

def toggle_resizable(self):
    """Toggle between resizable and fixed-size window."""
    self.flags ^= RESIZABLE
    pygame.display.set_mode(self.rect.size, self.flags)
```

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```
def toggle_frame(self):
    """Toggle between frame and noframe window."""
    self.flags ^= NOFRAME
    pygame.display.set_mode(self.rect.size, self.flags)
```

5.5 Add the Scene class

Most applications or games have different scenes, such as an introduction screen, an intro, and different game levels. So we are going to define the Scene class:

```
class Scene:
    """Create a new scene (room, level, view)."""
    id = 0
    bg = Color('gray')
```

When creating a new scene, we append the scene to the applications scene list and make this scene the current scene:

```
def __init__(self, *args, **kwargs):
    # Append the new scene and make it the current scene
    App.scenes.append(self)
    App.scene = self
```

Then we set a scene id, which is kept as class attribute of the Scene class. Then we set the nodes list to the empty list and set the background color:

```
# Set the instance id and increment the class id
self.id = Scene.id
Scene.id += 1
self.nodes = []
self.bg = Scene.bg
```

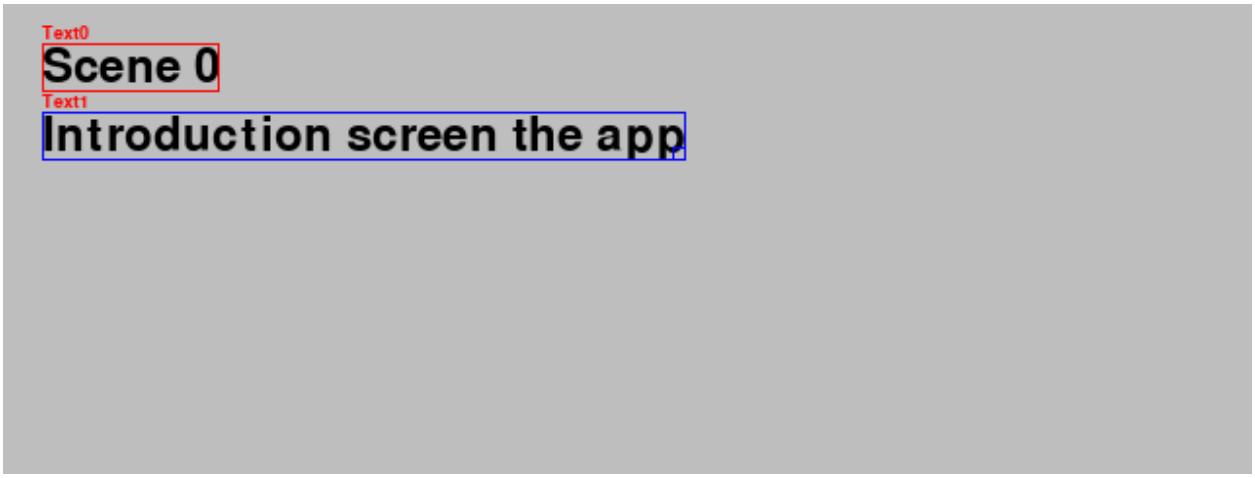
The scene object knows how to draw itself. It first fills the background with the background color, then draws each nodes and finally flips the display to update the screen:

```
def draw(self):
    """Draw all objects in the scene."""
    App.screen.fill(self.bg)
    for node in self.nodes:
        node.draw()
    pygame.display.flip()
```

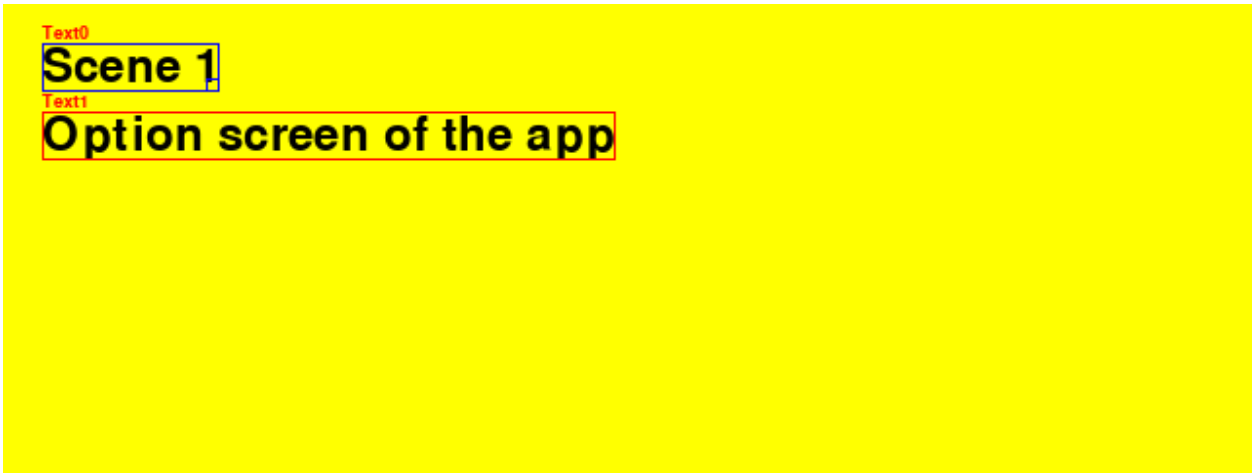
The string representation of the scene is *Scene* followed by its ID number:

```
def __str__(self):
    return 'Scene {}'.format(self.id)
```

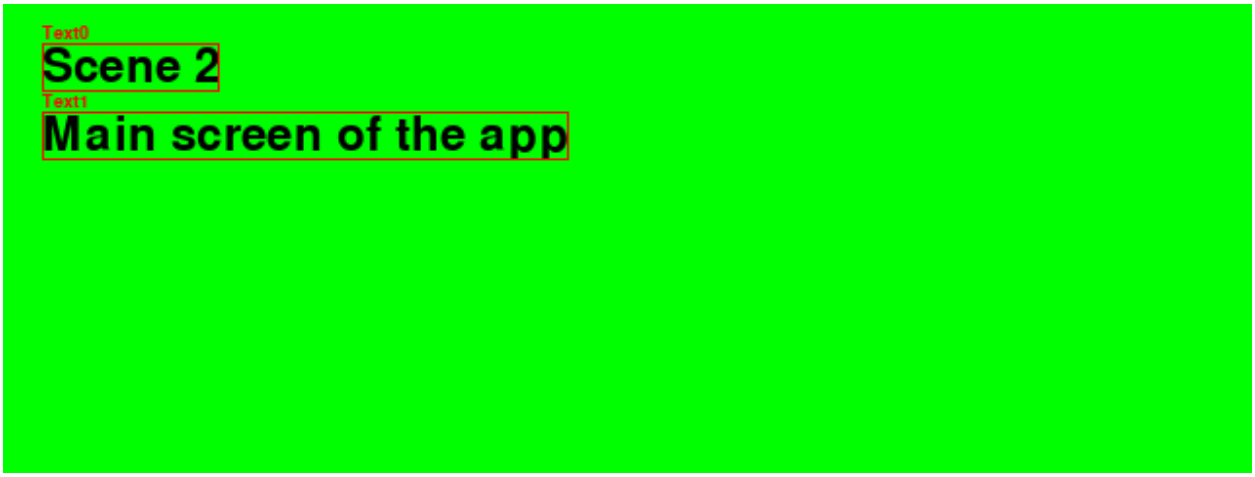
This is an image of scene 0 with two text objects and a default gray background color. The second text object has been selected.



This is an image of scene 1 with two text objects, the first one being selected and a yellow background color.



This is an image of scene 2 with two text objects, none being selected, and a green background color.



Here is the complete code:

```
from app import *
```

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```
class Demo(App):
    def __init__(self):
        super().__init__()

        Scene(caption='Intro')
        Text('Scene 0')
        Text('Introduction screen the app')

        Scene(bg=Color('yellow'), caption='Options')
        Text('Scene 1')
        Text('Option screen of the app')

        Scene(bg=Color('green'), caption='Main')
        Text('Scene 2')
        Text('Main screen of the app')

        App.scene = App.scenes[0]

if __name__ == '__main__':
    Demo().run()
```

5.6 Scenes with background images

We can add a background image to a scene:

```
self.file = Scene.options['file']

if self.file != '':
    self.img = pygame.image.load(self.file)
    size = App.screen.get_size()
    self.img = pygame.transform.smoothscale(self.img, size)
self.enter()
```

This is an image of scene 0 with a forest background image and a white Text object.

This is an image of scene 1 with a lake background image and a black Text object.

This is an image of scene 2 with a sunset background image and a white Text object.

Here is the complete code:

```
"""Display different scene background images."""
from app import *

class Demo(App):
    def __init__(self):
        super().__init__()
        Scene(img_folder='../background', file='forest.jpg', caption='Forest')
        Text('Forest scene', fontcolor=Color('white'))
        Scene(file='lake.jpg', caption='Lake')
        Text('Lake scene')
        Scene(file='sunset.jpg', caption='Sunset')
        Text('Sunset scene', fontcolor=Color('white'))
        Scene(file='', bg=Color('lightgreen'), caption='Green background')
        Text('Colored background scene')

if __name__ == '__main__':
    Demo().run()
```

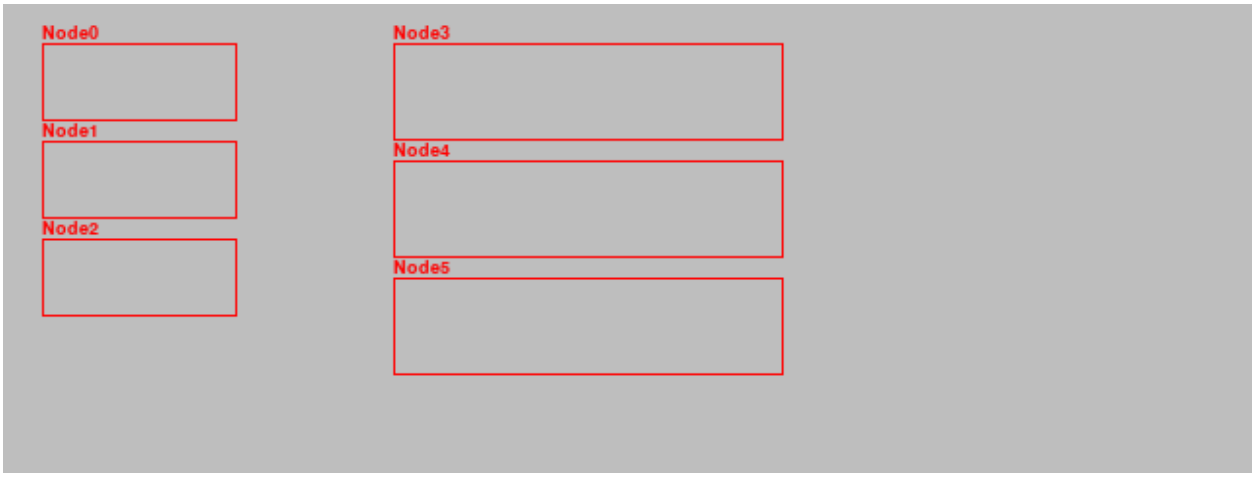
5.7 Automatic node placement

Nodes are containers for GUI elements. It is convenient if they can be placed automatically inside a scene.

- `pos` the current position
- `size` the current size
- `dir` the current direction: vertical (1, 0), horizontal (0, 1), diagonal (1, 1)
- `gap` the spacing

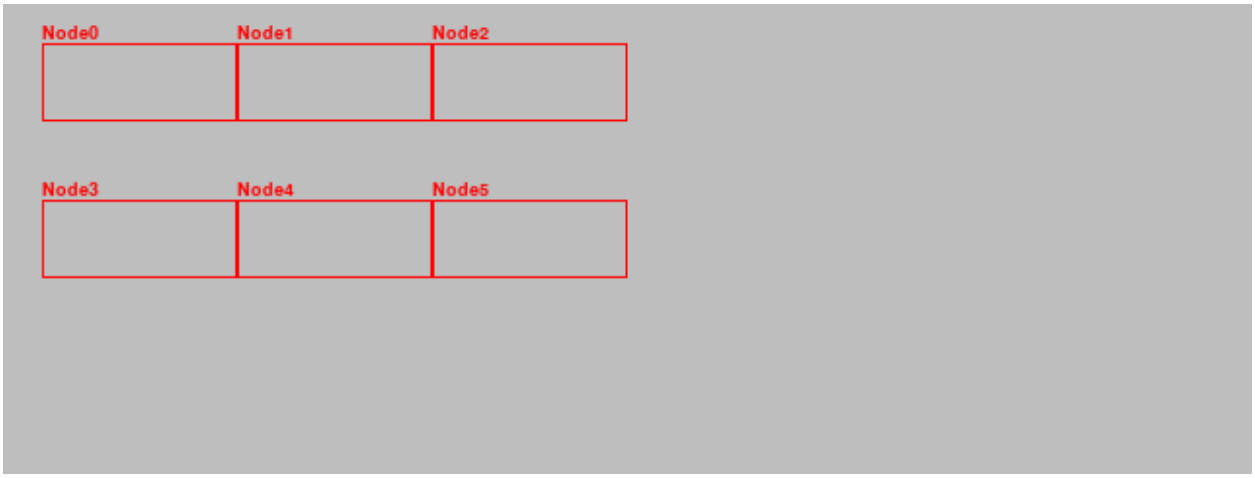
The default placement direction is vertical. Nodes placed in a scene stack up vertically. At any time the node position, node size, node gap or node direction can be changed:

```
Scene(caption='Nodes - vertical placement')
Node()
Node()
Node()

Node(pos=(200, 20))
Node()
Node()
```



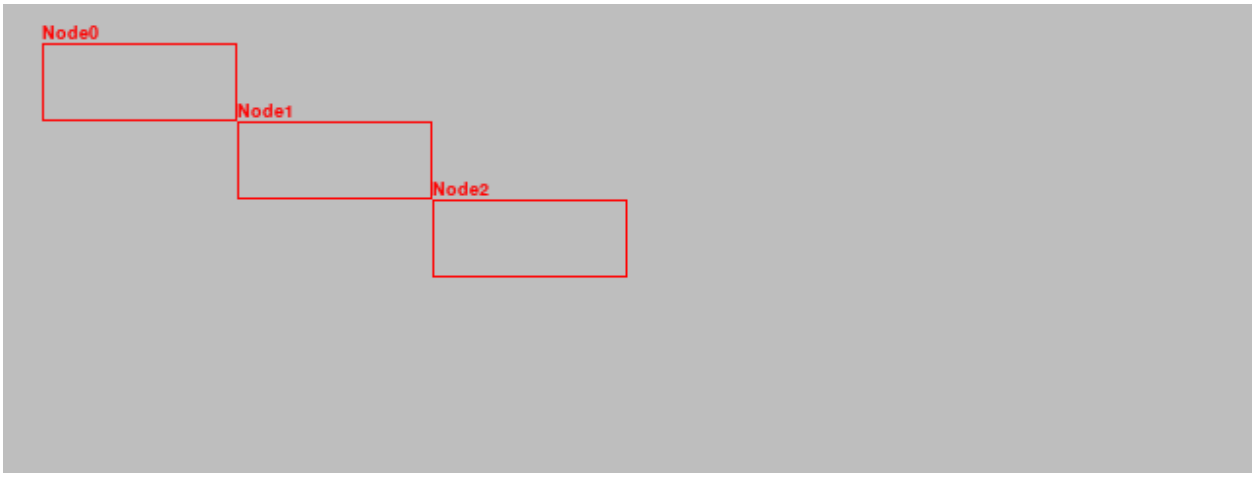
Here we change the node placement direction to horizontal, dir=(0, 1). At any time we can change the node position or gap. We can place the inital node position at (0, 0) and change the gap to (0, 0):

```
Scene(caption='Nodes - horizontal placement')
Node(dir=(1, 0), pos=(0, 0), gap=(0, 0))
Node()
Node()

Node(pos=(0, 100))
Node()
Node()
```



The placement can also be diagonal by chosing the direction vector dir = (1, 1):

```
Scene(caption='Nodes - diagonale placement')
Node(dir=(1, 1), gap=(0, 0))
Node()
Node()
```



Here is the complete code:

```
from app import *

class Demo(App):
    def __init__(self):
        super().__init__()

        Scene(caption='Nodes - vertical placement')
        Node()
        Node()
        Node()

        Node(pos=(200, 20), size=(200, 50))
        Node()
        Node()

        Scene(caption='Nodes - horizontal placement')
```

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```
        Node(dir=(1, 0), gap=(0, 0))
        Node()
        Node()

        Node(pos=(20, 100)
        Node()
        Node()

        Scene(caption='Nodes - diagonal placement')
        Node(dir=(1, 1), gap=(0, 0))
        Node()
        Node()

if __name__ == '__main__':
    Demo().run()
```

CHAPTER 6

Create a graphical user interface (GUI)

The graphical user interface (GUI) consists of all the elements the user can interact with (read, click, drag, resize, select, input):

- text
- button
- checkbutton
- radiobutton
- menu (pop-up, pull-down)
- listboxe
- slider

6.1 Text attributes

We store all pygame text attributes as class variables:

```
class Text(Node):
    """Create a text object which knows how to draw itself."""

    fontname = None
    fontsize = 36
    fontcolor = Color('black')
    background = None
    italic = False
    bold = False
    underline = False
```

After initializing the Node, we update the instance variables from the Text class variables:

```
super().__init__(**options)
self.__dict__.update(Text.options)
```

The font size and the three styles (bold, italic, underline) are set at font creation:

```
def set_font(self):
     """Set the font and its properties."""
     self.font = pygame.font.Font(self.fontname, self.fontsize)
     self.font.set_bold(self.bold)
     self.font.set_italic(self.italic)
     self.font.set_underline(self.underline)
```

The font color and the background color are set when rendering the text:

```
def render(self):
    """Render the text into an image."""
    self.img = self.font.render(self.text, True, self.fontcolor, self.background)
    self.rect.size = self.img.get_size()
```

Here is a code example:

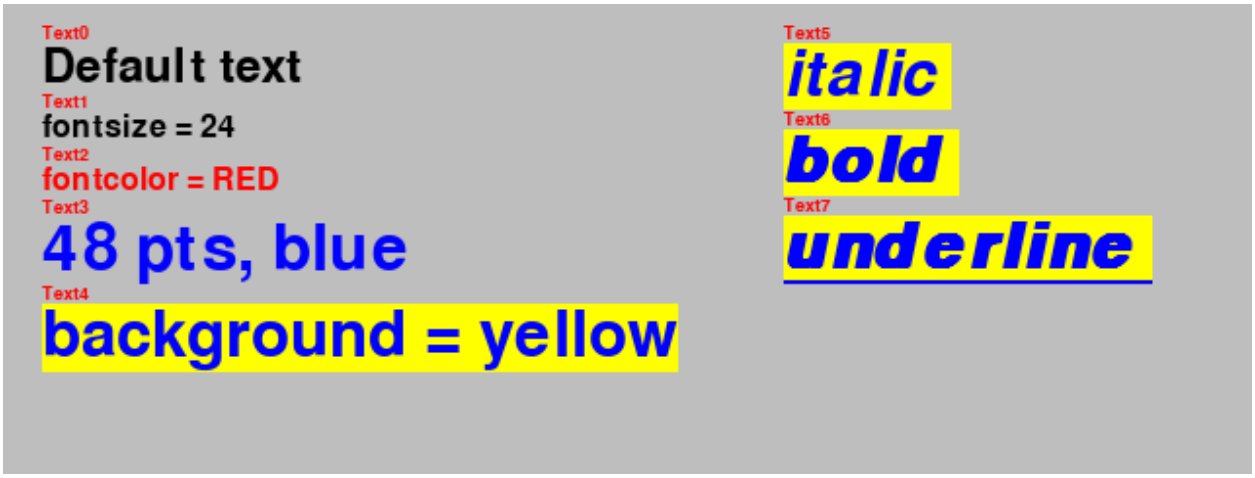
```
"""Display text with different size, color and font."""
from app import *

class Demo(App):
    def __init__(self):
        super().__init__()
        Scene(caption='Text')
        Text('Default text')
        Text('fontsize = 24', fontsize=24)
        Text('fontcolor = RED', fontcolor=Color('red'))
        Text('48 pts, blue', fontsize=48, fontcolor=Color('blue'))
        Text('fontbg = yellow', fontbg=Color('yellow'))

        Text('italic', pos=(400, 20), italic=True)
        Text('bold', bold=True)
        Text('underline', underline=True, font_bg=None)

if __name__ == '__main__':
    Demo().run()
```

Which produces this result:



6.2 Horizontal and vertical alignment

For a given box size, text can be aligned horizontally to the left, center, or right. The following code aligns the text image with these three positions:

```
w, h = self.rect.size
w0, h0 = self.text_img.get_size()

if self.h_align == 0:
    x = 0
elif self.h_align == 1:
    x = (w-w0)//2
else:
    x = w-w0
```

In the vertical direction the text image can be aligned at the top, middle or bottom:

```
if self.v_align == 0:
    y = 0
elif self.v_align == 1:
    y = (h-h0)//2
else:
    y = h-h0

self.img0.blit(self.text_img, (x, y))
self.img = self.img0.copy()
```

The image *img0* is the orignal, used for scaling. The *img* is the one used for drawing.

Here is a code example:

```
"""Horizontal and vertical text alignement."""
from app import *

class Demo(App):
    def __init__(self):
        super().__init__()

        Scene(caption='Text Alignment', bg=Color('pink'))
```

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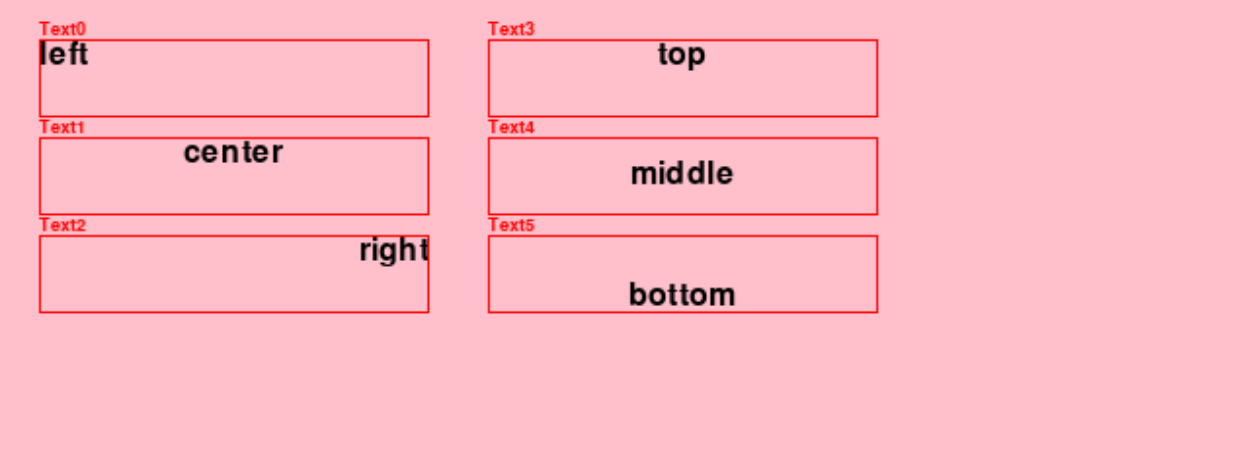
```
        Text('left', size=(200, 40), fontsize=24)
        Text('center', h_align=1)
        Text('right', h_align=2)
        Text(bg=Color('blue'), fontcolor=Color('white'))

        Text('top', pos=(250, 20), h_align=1)
        Text('middle', v_align=1)
        Text('bottom', v_align=2)

if __name__ == '__main__':
    Demo().run()
```

Which produces the following result:



6.3 Text attributes

A Text object has various attributes which are remembered.

Here is a code example:

```
"""Text with size, alignment, fontcolor, font background..."""
from app import *

class Demo(App):
    def __init__(self):
        super().__init__()

        Scene(caption='Text', bg=Color('pink'))
        Text(size=(100, 40))
        Text(bg=Color('yellow'), h_align=1)
        Text(fontcolor=Color('red'))
        Text(fontbg=Color('green'), cmd='print(self.text)')

        Text(pos=(200, 20))
        Text(italic=True, v_align=1)
        Text(underline=True, fontsize=24)
        Text(bold=True)
```

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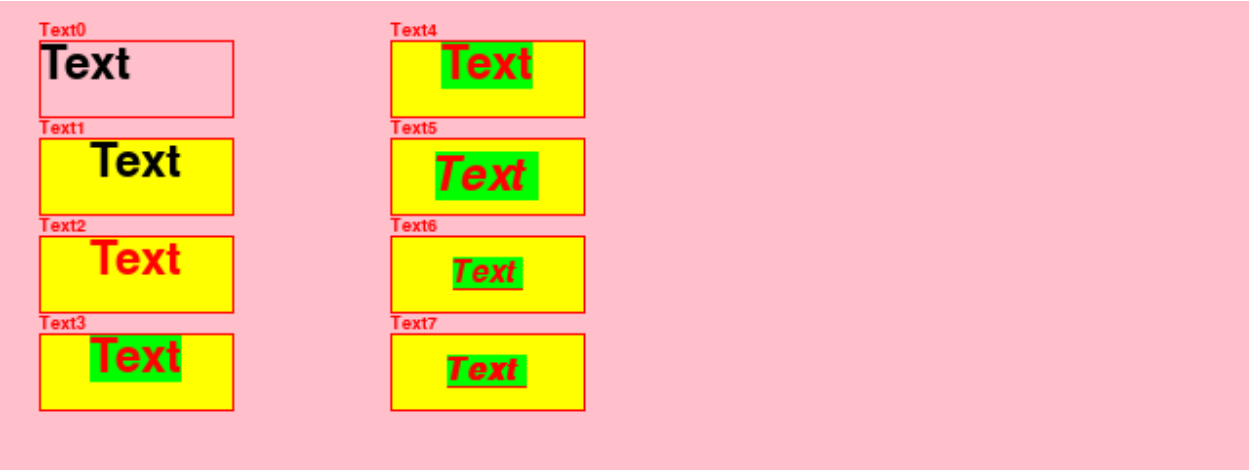
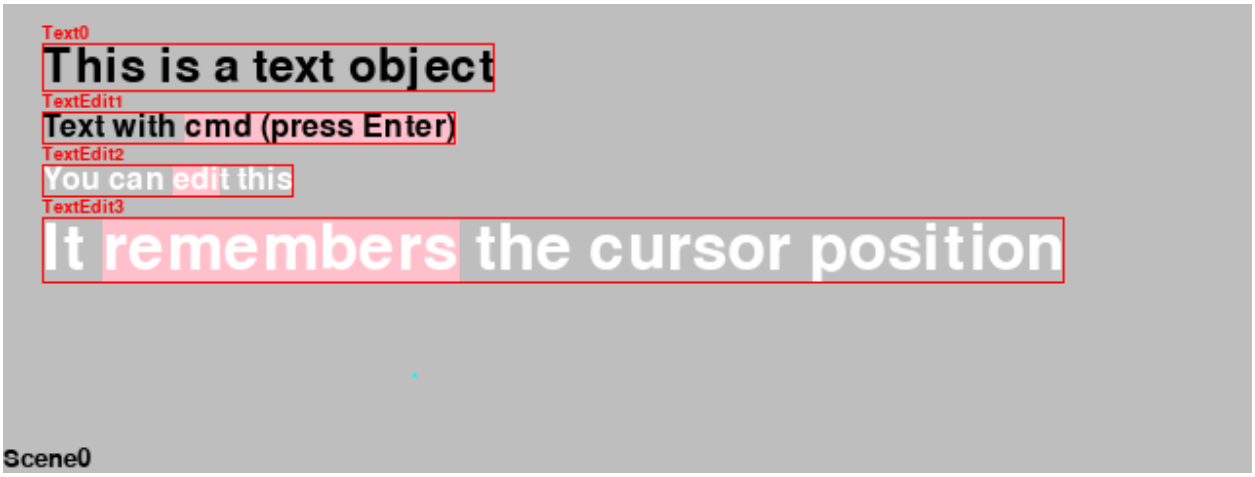
```
if __name__ == '__main__':
    Demo().run()
```

It produces the following result:



6.4 Editable text

The class `TextEdit` provides editable text with a movable cursor. The cursor is represented as a small rectangle which is rendered under the text. A selection is represented as a large rectangle under the selected letters.



6.4.1 Create the cursor

The class attribute `TextEdit.cursor` defines the cursor color and width:

```
cursor = Color('red'), 2  # cursor color and width
```

Inside the conxtructor, the cursor is placed at the end of the text. A cursor image is created and filled with the cursor color. The cursor rectangle is initally placed at the end of the text:

```
col, d = TextEdit.cursor
self.cursor = len(self.text)
self.cursor_img = pygame.Surface((d, self.rect.height))
self.cursor_img.fill(col)
self.cursor_rect = self.cursor_img.get_rect()
self.cursor_rect.topleft = self.rect.topright
```

6.4.2 Get the character index

The cursor is represented as an integer index in the range [0 .. n] where n is the lenght of the text. Each letter has a different width. The list `self.char_positions` remembers the x position of each letter:

```
def set_char_positions(self):
    """Get a list of all character positions."""
    self.char_positions = [0]
    for i in range(len(self.text)):
        w, h = self.font.size(self.text[:i+1])
        self.char_positions.append(w)
```

When we click with the mouse anywhere in the text, we need to know the character index:

```
def get_char_index(self, position):
    """Return the character index for a given position."""
    for i, pos in enumerate(self.char_positions):
        if position <= pos:
            return i
    # if not found return the highest index
    return i
```

6.4.3 Move the cursor

The arrow keys allow to move the cursor to the left or to the right. The argument `d` is 1 or -1 and indicates the direction of movement. The cursor movement is limit to the interval [0 .. n]:

```
def move_cursor(self, d):
    """Move the cursor by d charactors, and limit to text length."""
    mod = pygame.key.get_mods()
    n = len(self.text)
    i = min(max(0, self.cursor+d), n)
```

Pressing the CMD key, the cursor goes all the way to the beginning or the end of the line:

```
if mod & KMOD_META:
    if d == 1:
        i = n
    else:
        i = 0
```

Pressing the ALT key, the cursor goes to the end of the word:

```
if mod & KMOD_ALT:
    while (0 < i < n) and self.text[i] != ' ':
        i += d
```

Pressing the SHIFT key prevents cursor2 from moving, thus setting a selection:

```
if not mod & KMOD_SHIFT:
    self.cursor2 = i

self.cursor = i
```

6.4.4 Copy, cut and insert text

The two cursors can be inverted. The following method returns the two cursors (selection indices) in the right order:

```
def get_selection_indices(self):
    """Get ordered tuple of selection indicies."""
    i = self.cursor
    i2 = self.cursor2

    if i < i2:
        return i, i2
    else:
        return i2, i
```

To copy text we save the selection in a Scene variable `text`:

```
def copy_text(self):
    """Copy text to Scene.text buffer."""
    i, i2 = self.get_selection_indices()
    text = self.text[i:i2]
    App.scene.text = text
```

To cut text we copy the text and replace the selection with an empty string:

```
def cut_text(self):
    """Cut text and place copy in Scene.text buffer."""
    self.copy_text()
    self.insert_text('')
```

To insert text we replace the current selection with the new text:

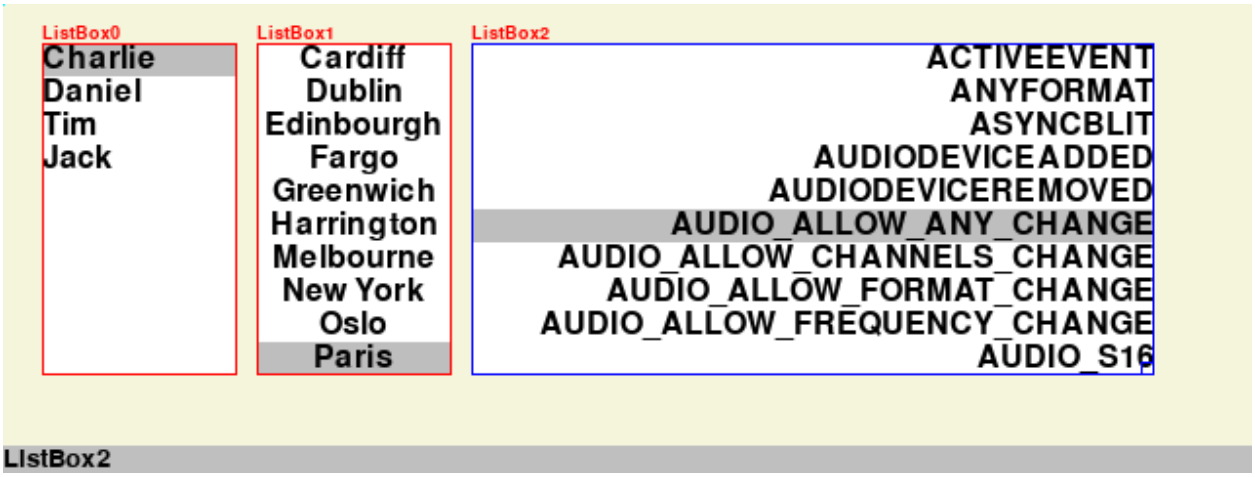
```
def insert_text(self, text):
    """Insert text at the cursor position or replace selection."""
    i, i2 = self.get_selection_indices()
    text1 = self.text[:i]
    text2 = self.text[i2:]
    self.text = text1 + text + text2
    self.cursor = i + len(text)
    self.cursor2 = self.cursor
```

6.5 Buttons

The button class displays a text and executes a command upon a mouse-click

6.6 ListBox

The ListBox class displays a list of items. One item can be selected with a mouse-click or with the UP/DOWN arrow keys. Pressing the RETURN key executes the command.



6.7 Detecting double-clicks

In order to detect double-clicks or multiple clicks we need to use a timer event. The reason for using a timer is that we cannot know at the time of a mouse click if there are more clicks to follow. We only know for sure after a short timeout period. So we define a new event as the first USEREVENT:

```
DBL_CLICK_TIMER = pygame.USEREVENT
DBL_CLICK_TIMEOUT = 250
```

Inside the `Scene.do_event()` we look for a MOUSEBUTTONDOWN event and we set a timer and increment the clicks:

```
if event.type == MOUSEBUTTONDOWN:
    pygame.time.set_timer(DBL_CLICK_TIMER, DBL_CLICK_TIMEOUT)
    self.clicks += 1
```

Once the timeout occurs, we

- reset (disable) the timer
- print the number of clicks and
- reset the click count to zero:

```
elif event.type == DBL_CLICK_TIMER:
    pygame.time.set_time(DBL_CLICK_TIMER, 0)
    print(self.clicks, 'clicks in', self.focus)
    self.clicks = 0
```

The text printed to the console looks like this:

```
2 clicks in Text0
4 clicks in Text0
3 clicks in Ellipse1
1 clicks in Rectangle2
2 clicks in None
```

CHAPTER 7

Playing sound

7.1 Making sounds

The `pygame.mixer` module allows to play compressed OGG files or uncompressed WAV files.

This checks the initialization parameters and prints the number of channels available. It opens a sound object and prays it:

```
print('init =', pygame.mixer.get_init())
print('channels =', pygame.mixer.get_num_channels())
App.snd = pygame.mixer.Sound('5_app/rpgaudio.ogg')
App.snd.play()
print('length =', App.snd.get_length())
```

Writes this to the console:

```
init = (22050, -16, 2)
channels = 8
length = 28.437868118286133
```

Here is a code example:

```
"""Play a sound."""
from app import *

class Demo(App):
    def __init__(self):
        super().__init__()

        print('init =', pygame.mixer.get_init())
        print('channels =', pygame.mixer.get_num_channels())
        App.snd = pygame.mixer.Sound('5_app/rpgaudio.ogg')
        App.snd.play()
        print('length =', App.snd.get_length())
```

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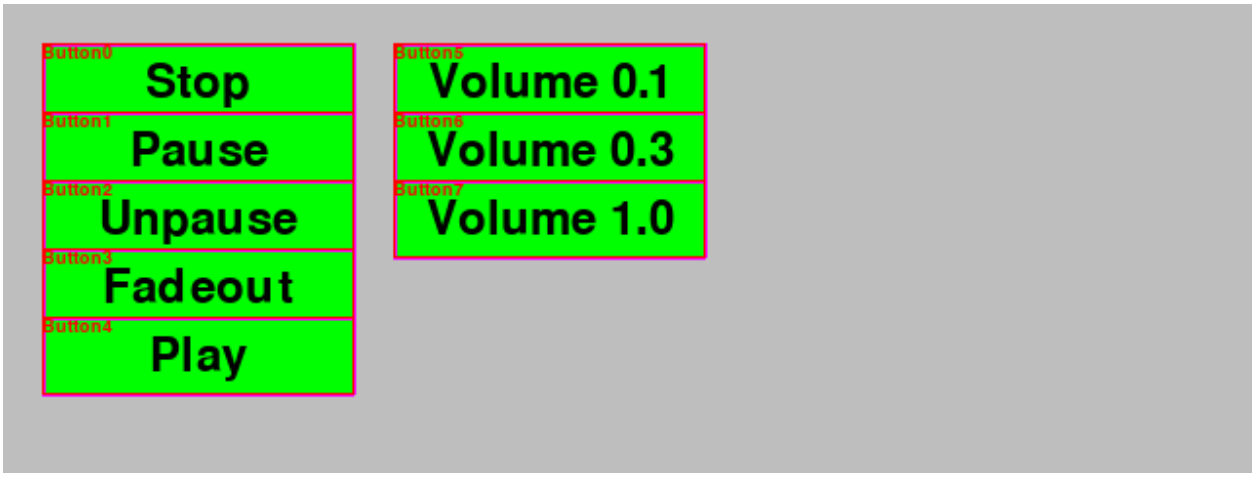
```
        Scene(caption='Sound mixer')
        Button('Stop', cmd='pygame.mixer.stop()')
        Button('Pause', cmd='pygame.mixer.pause()')
        Button('Unpause', cmd='pygame.mixer.unpause()')
        Button('Fadeout', cmd='pygame.mixer.fadeout(5000)')
        Button('Play', cmd='App.snd.play()')
        Button('Volume 0.1', cmd='App.snd.set_volume(0.1)', pos=(200, 20))
        Button('Volume 0.3', cmd='App.snd.set_volume(0.3)')
        Button('Volume 1.0', cmd='App.snd.set_volume(1.0)')

if __name__ == '__main__':
    Demo().run()
```

Which produces the following result.

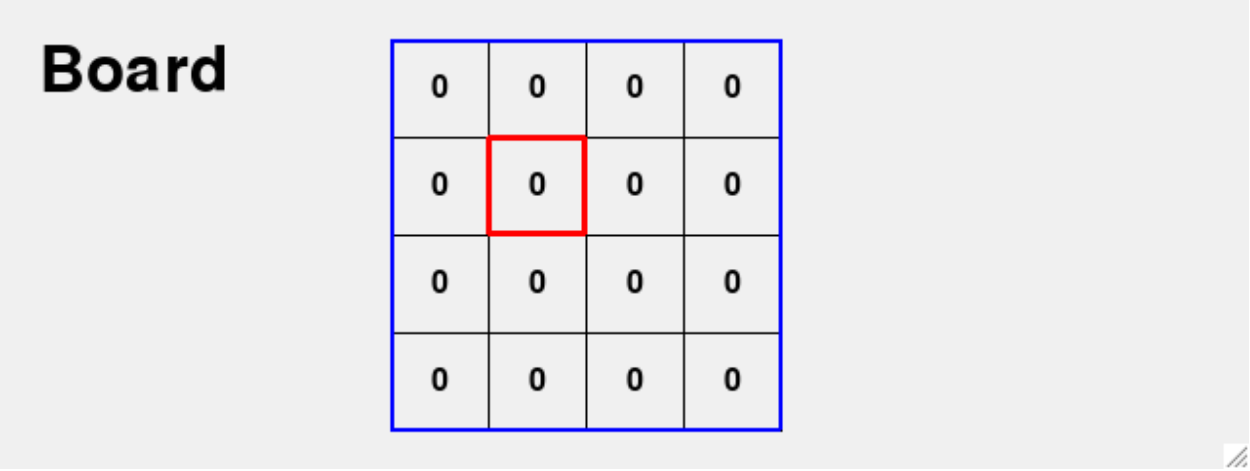


CHAPTER 8

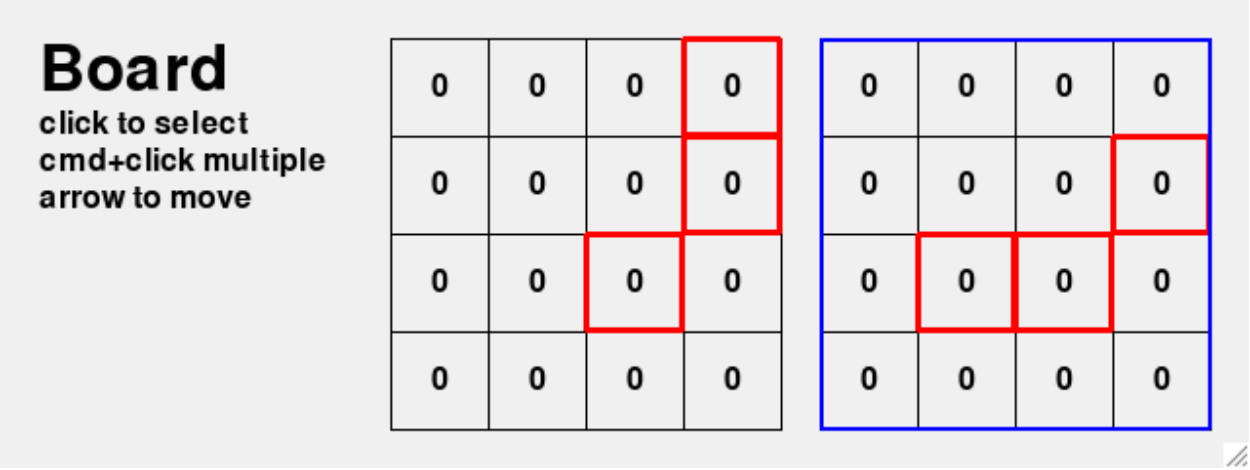
Board Games

In this section we create the framework for board games. These games are based on a nxm grid. Each cell can have

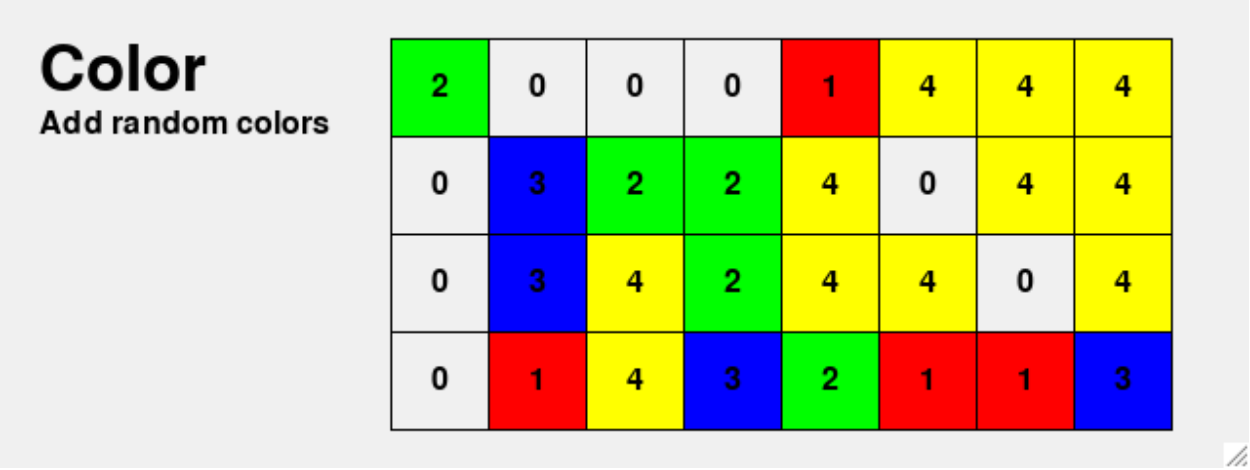
- text
- color
- image



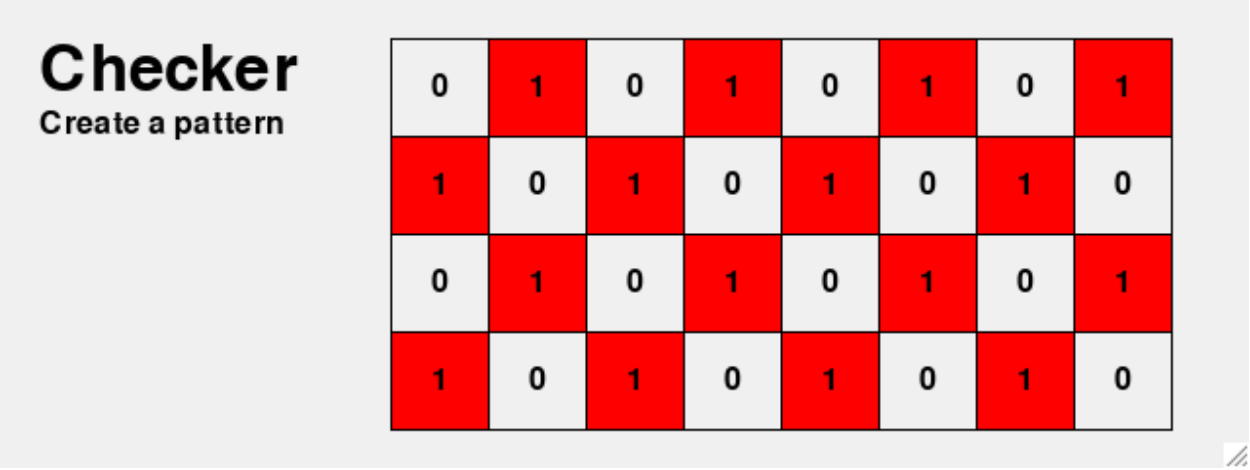
8.1 Selecting cells with the mouse



8.2 Adding background color



8.3 Create a checkerboard pattern



CHAPTER 9

About Sphinx

Sphinx is a tool for making documentation. It was originally created for the Python documentation, but is now used for many other software projects.

Sphinx uses *reStructuredText* as its markup language. It can produce HTML, LaTeX, ePub and PDF documents.

Source: https://www.sphinx-doc.org

9.1 Getting started

After installation, you can get started quickly with the tool **`sphinx-quickstart`**. Just enter:

```
sphinx-quickstart
```

Answer each customization question with yes or no. Be sure to say **yes** to the **autodoc** extension. The **`sphinx-quickstart`** creates a directory with several documents:

- `conf.py` file, the *default configuration file*
- `index.rst` file, the *master document*

The `conf.py` file let's you configure all aspects of Sphinx. The `index.rst` is the entry page for your documentation. It contains the `toctree` directive which determines the files to include. For this project it looks like this:

```
.. toctree::
   :maxdepth: 2
   :caption: Contents:

   1_intro/intro
   2_draw/draw
   3_image/image
   ...
```

To build the HTML pages just run:

```
make html
```

To make the PDF document run:

```
make pdf
```

9.2 reStructuredText

reStructuredText (.rst) is the default markup language used with Sphinx. It is important to know that:

- paragraphs are separated by one or more blank lines
- indentation is significant

9.2.1 Inline styles

Inside text you can use:

- one asterisk for *italics*
- two asterisks for **bold**
- backquotes for `code`

9.2.2 Lists

This code:

```
* This is a bulleted list.
* It has two items, the second
  item uses two lines.

#. This is a numbered list.
#. It has two items too.
```

produces this result:

- This is a bulleted list.
- It has two items, the second item uses two lines.

1. This is a numbered list.
2. It has two items too.

9.2.3 Hyperlinks

This code:

```
`Source <https://www.sphinx-doc.org>`_
```

produces Source

9.2.4 Admonitions

Danger: Be careful with this code!

Tip: Be careful with this code!

Warning: Be careful with this code!

9.2.5 Footnotes

This is a footnote[1] inside a text, this is another one[2].

9.2.6 Horizontal list

To add a horizontal list add this code:

```
.. hlist::
   :columns: 3

   * happy
   ...
```

- happy
- short
- intelligent
- thankful
- displayed
- horizontal

9.2.7 Download

To add a download link add this code:

```
:download:`requirements.txt<requirements.txt>`.
```

requirements.txt.

9.3 Include from a file

It is possible to include a Python object (class, method) from a file. For example you can include a **class** definition with:

[1] Text of the first footnote
[2] Text of the second footnote

```
.. literalinclude:: 5_app/app.py
   :pyobject: Rectangle
   :linenos:
   :emphasize-lines: 5-7
```

resulting in

```
1  class Rectangle(Node):
2      """Draw a rectangle on the screen."""
3      options = { 'fg': Color('green'),
4                  'bg': Color('black'),
5                  'thickness': 2}
6
7      def __init__(self, **options):
8          super().__init__(**options)
9          self.set_options(Rectangle, options)
10         self.render()
11
12     def render(self):
13         self.img0 = pygame.Surface(self.rect.size, flags=SRCALPHA)
14         if self.fg != None:
15             pygame.draw.rect(self.img0, self.fg, Rect(0, 0, *self.rect.size), 0)
16         pygame.draw.rect(self.img0, self.bg, Rect(0, 0, *self.rect.size), self.
   ↪thickness)
17         self.img = self.img0.copy()
```

Or you can include just a **method** definition with:

```
.. literalinclude:: 5_app/app.py
   :pyobject: Rectangle.render
```

resulting in

```
    def render(self):
        self.img0 = pygame.Surface(self.rect.size, flags=SRCALPHA)
        if self.fg != None:
            pygame.draw.rect(self.img0, self.fg, Rect(0, 0, *self.rect.size), 0)
        pygame.draw.rect(self.img0, self.bg, Rect(0, 0, *self.rect.size), self.
↪thickness)
        self.img = self.img0.copy()
```

9.4 Directives

A directive consists of

- name
- arguments
- options
- content

The structure is this:

```
.. name:: arguments
   :option: value

   content
```

9.4.1 Function

This directive defines a function:

```
.. function:: spam(eggs)
              ham(eggs)

   Spam ham ham the are made with a certain number of eggs.
```

spam(*eggs*)
ham(*eggs*)
Spam and ham the are made with a certain number of eggs.

To cross-reference you can use:

- `method_name()` with `:meth:`method_name``
- `class_name` with `:class:`class_name``
- `function_name()` with `:func:`function_name``

For example with `:func:`spam`` one can refernce the above functions *spam()* or *ham()* inside a sentence..

9.4.2 Data

To describe global data and constants in a module use this code:

```
.. data:: number=1000

   Describe data.
```

produces

number=1000
Describe data.

9.4.3 Class

class App
Describe class without parameters.

run()

Describe the method.

class App(*parameters*)
Describe class with parameters.

objects

Global class attribute.

9.4.4 Functions with arguments

send_message(*sender*, *recipient*, *message_body*[, *priority=1*])
Send a message to a recipient

Parameters

- **sender** (*str*) – The person sending the message
- **recipient** (*str*) – The recipient of the message
- **message_body** (*str*) – The body of the message
- **priority** (*integer or None*) – The priority of the message, can be a number 1-5

Returns the message id

Return type int

Raises

- **ValueError** – if the message_body exceeds 160 characters
- **TypeError** – if the message_body is not a basestring

9.5 Math formulas

Since Pythagoras, we know that $a^2 + b^2 = c^2$.

$$e^{i\pi} + 1 = 0 \tag{9.1}$$

Euler's identity, equation (9.1), was elected one of the most beautiful mathematical formulas.

9.6 The app module

This code:

```
.. automodule:: app
   :members:
   :member-order: bysource
```

Prints the whole app documentation and lists members by source order.

App - there is only one App object - an app has multiple scenes (App.scenes) - an app has one current scene (App.scene) - an app has one window to draw in (App.screen)

Scene

- a scene has multiple nodes (App.scene.nodes)
- nodes are ordered: the last in the list is displayed last
- the node which is clicked becomes active
- the active node becomes the top node
- the active node has focus (App.scene.focus)
- TAB and shift-TAB select the next node

Node (object)

- nodes have default position and size (pos, size)
- nodes are automatically placed at creation (dir, gap)
- nodes inherit options (color, size, . . .) from the previous object

A Node object has the following properties

- clickable: mouse-click has effect
- movable: can be moved (mouse, arrow-keys)
- visible: is drawn
- has focus

Debug

- print events to console (cmd+E)
- display node label (cmd+L)
- display outline (cmd+O)

class app.**App**(*size=(640, 240)*, *shortcuts={}*)
Create a single-window app with multiple scenes having multiple objects.

run()
Run the main event loop.

next_scene(*d=1*)
Switch to the next scene.

do_shortcut(*event*)
Find the key/mod combination in the dictionary and execute the cmd.

capture()
Save a screen capture to the directory of the calling class, under the class name in PNG format.

toggle_fullscreen()
Toggle between full screen and windowed screen.

toggle_resizable()
Toggle between resizable and fixed-size window.

toggle_frame()
Toggle between frame and noframe window.

class app.**Scene**(*caption='Pygame'*, *remember=True*, ***options*)
Create a new scene and initialize the node options.

load_img(*file*)
Load the background image.

enter()
Enter a scene.

update()
Update the nodes in a scene.

set_status(*txt*)
Set status text and render it.

render_status()
Render the status text.

draw()
Draw all objects in the scene.

do_event(*event*)
Handle the events of the scene.

next_focus(*d=1*)
Advance focus to next node.

cut()
Cuts the selected objects and places them in App.selection.

copy()
Copies the selected objects and places them in App.selection.

paste()
Pastes the objects from App.selection.

debug()
Print all scene/node options.

class app.**Node**(***options*)
Create a node object with automatic position and inherited size.

set_options(*cls*, *options*)
Set instance options from class options.

create_img()
Create the image surface, and the original img0.

color_img()
Add background color to the image.

set_background(*img*)
Set background color or transparency.

load_img()
Load the image file.

calculate_pos(*options*)
Calculate the next node position.

render_label()
Create and render the node label.

do_event(*event*)
React to events happening for focus node.

draw()
Draw the node and optionally the outline, label and focus.

class app.**TextObj**(*text='Text'*, ***options*)
Create a text surface image.

set_font()
Set the font and its properties.

render_text()
Render the text into an image.

class app.**Text**(*text='Text'*, ***options*)
Create a text object horizontal and vertical alignement.

class app.**TextLines**(*text*, ***options*)

class app.**EditableTextObj**(*text='EditableText'*, *cmd=''*, ***options*)
Create keyboard and mouse-editable text with cursor and selection.

set_char_positions()
Make a list of all character positions.

get_char_index(*position*)
Return the character index for a given position.

move_cursor(*d*)
Move the cursor by d characters, and limit to text length.

get_selection()
Get ordered tuple of selection indices.

copy_text()
Copy text to Scene.text buffer.

cut_text()
Cut text and place copy in Scene.text buffer.

insert_text(*text*)
Insert text at the cursor position or replace selection.

select_word()
Select word at current position.

select_all()
Select the whole text.

do_event(*event*)
Move cursor, handle selection, add/backspace text, copy/paste.

render()
Render cursor, selection and text to an image.

class app.**EditableText**(*text='CursorText'*, ***options*)
Create an editable text node.

do_event(*event*)
React to events happening for focus node.

draw()
Draw the node and optionally the outline, label and focus.

double_click()
Select the current word.

class app.**Button**(*text='Button'*, *cmd=''*, ***options*)
Create a button object with command.

do_event(*event*)
React to events happening for focus node.

class app.**Toggle**
Add toggle button behavior.

class app.**Checkbox**(***options*)

class app.**Radiobutton**(***options*)

class app.**ListBox**(*items*, *i=0*, ***options*)
Show a list of text items.

set_list(*items*)
Set items and selection list.

scroll(*d*)
Scroll listbox up and down.

move_cursor(*d*)
Move the active cell up or down.

do_event(*event*)
React to events happening for focus node.

class app.**ListMenu**(*items*, ***options*)
Display a drop-down menu.

class app.**SliderObj**(****options*)
Define a slider object.

class app.**Slider**(****options*)

do_event(*event*)
React to events happening for focus node.

class app.**Spinbox**(****options*)
Input a number.

do_event(*event*)
React to events happening for focus node.

class app.**Rectangle**(****options*)
Draw a rectangle on the screen.

class app.**Ellipse**(****options*)
Draw an ellipse on the screen.

class app.**Board**(****options*)
Draw a mxn board grid with m lines and n columns. m, n number of cells (row, col) i, j index of cell (row, col) dx, dy size of cell Num numeric matrix Num0 initial numeric matrix Col color matrix

set_Num(*s*)
Load Num table from a string.

render_colors()
Render the background colors.

render_grid()
Render the grid lines.

render_num()
Draw number.

render_tile()
Draw number.

render()
Render the whole board.

get_index(*x*, *y*)
Get index (i, j) from mouse position (x, y).

do_event(*event*)
React to events.

class app.**Sudoku**(***options*)
Create a sudoko game board.

render_grid()
Override the grid lines.

class app.**Chess**(***options*)
Create a sudoko game board.

class app.**Go**(***options*)

render()
Render the Go board and add extra dots on certain intersections.

class app.**Puzzle**(*div=(3, 3)*, ***options*)
Take an image and create a puzzle.

9.7 Glossary

reStructuredText reStructedText is ligh-weight markup langage.

CHAPTER 10

Indices and tables

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Python Module Index

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