

# Beginning Games Programming with Pygame Zero

## Introduction

This is a worksheet for a hands-on guide to creating a first game with Pygame Zero. You will create a simple graphical game. In this game the player will control a character that can be moved around the screen to find food. The food must be collected before time runs out.



## Installing Pygame Zero

Pygame Zero comes pre-installed on the Raspberry Pi, but needs to be installed on most other systems. The simplest way to install Pygame Zero on other systems is to install the Mu editor which comes as a bundle with Pygame Zero installed. I also recommend the Mu editor on the Raspberry Pi (which needs to be installed) as it's the easiest way to get started.

If using a Raspberry Pi then you can install Mu using

```
sudo apt install mu
```

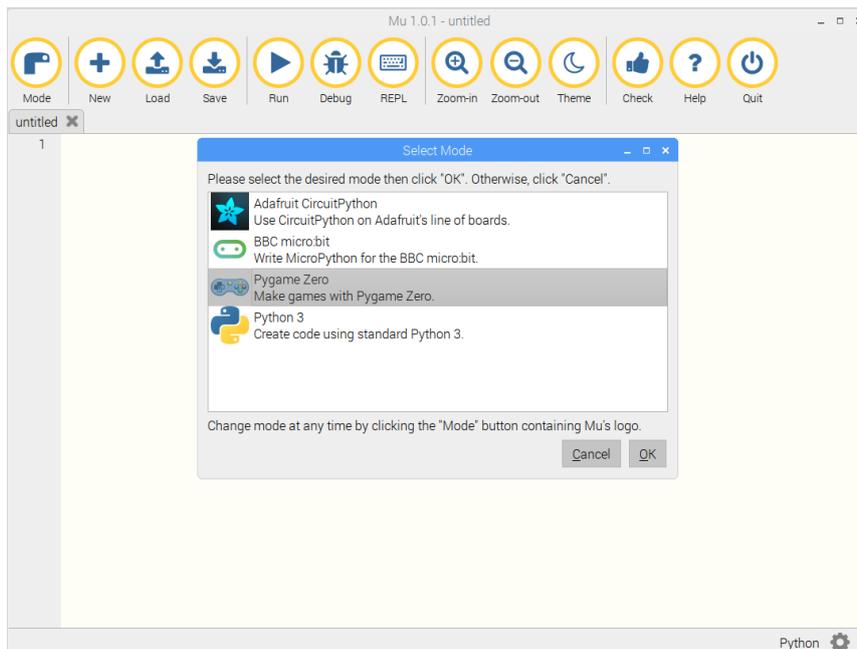
for other operating systems it can be downloaded from <https://codewith.mu/> (or see the instructions for just installing Pygame Zero from <https://pygame-zero.readthedocs.io/en/latest/installation.html> ).

You can then run Mu from the programming category in the application menu, or by typing `mu-editor` from the command line.

If you can't or don't want to use Mu you can use any other editor on your system (eg. Leafpad or Notepad), but you will then need to run the program from the command-line using `pgzrun`.

## Getting Started with Mu

When you first start Mu then it will ask what mode you wish to run in. Unsurprisingly you should select Pygame Zero. If you need to change the mode in future you can change the mode using the “Mode” button menu (top left).



To get started and test that everything is setup correctly create a first program file with the following two lines:

```
WIDTH = 800  
HEIGHT = 600
```

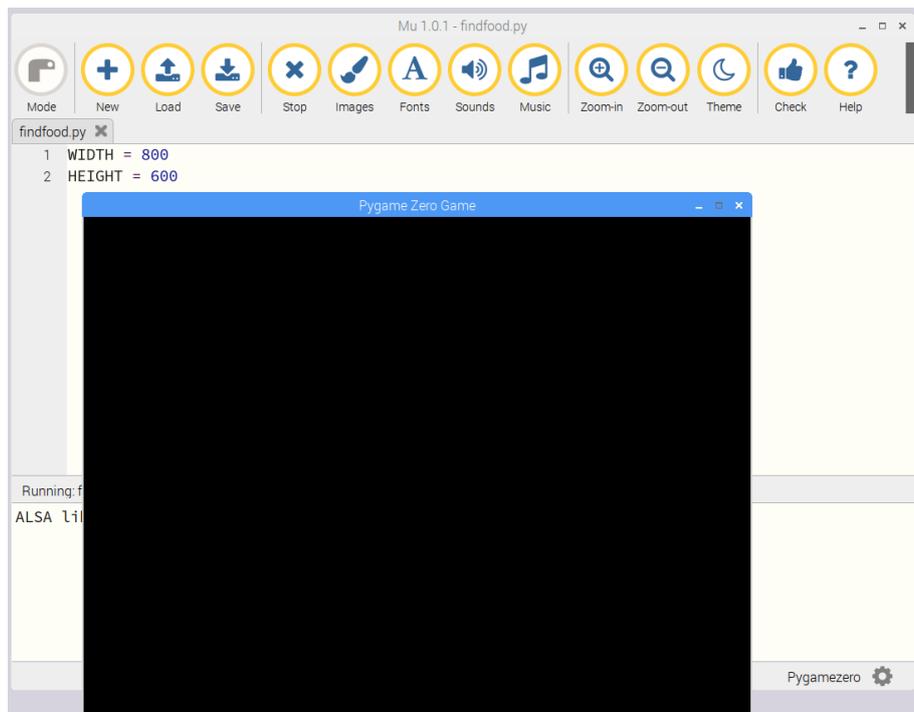
Save it as `findfood.py`

To test from Mu click on the Play button. You will need to save the file which by default is stored in the `mu_code` directory.

If you want to run the program from outside of Mu then change to the appropriate directory and enter

```
pgzrun findfood.py
```

When run you the program should create a new windows with a black background.



You can close the program by clicking on the x in the top right, or by pressing Stop from the Mu menubar.

You've now created your first Pygame Zero file.

## Adding a Background Image

You are now going to need some image files to include in the game. I have collected some images that are suitable for the game, but feel free to choose something different or create your own if you prefer.

You can get the required files from:

<http://www.penguintutor.com/downloads/findfood-gamefiles.tgz>

unzip them to your home directory using:

```
cd ~  
tar -xvzf findfood-gamefiles.tgz
```

All the code files should be stored in the mu\_code directory and in the case of the images into a sub directory images.

This can be achieved through the file explorer or the following from the command line

```
cp ~/finding-food/images/* ~/mu_code/images/
```

Before starting the sprites you can replace the black background with a background image. This can be achieved by adding the following line into your code (after the current WIDTH and HEIGHT entries).

```
BACKGROUND_IMG = "grass-field"  
  
def draw():  
    screen.blit(BACKGROUND_IMG, (0,0))
```

Click on the Play button and you should now see the same screen from before, but it will now have a green background.

This works by defining BACKGROUND\_IMG which is a variable that holds the name of the image. The image is entered as the filename without any path information or the .png suffix. On recent versions of Pygame Zero then you can use the full filename if you prefer, but to maintain compatibility with older versions of Pygame Zero the files must be in the images folder and not include the suffix. This is the same for any images.

The line

```
def draw():
```

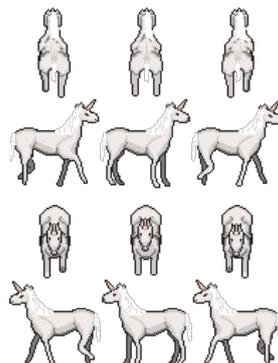
is defining the draw function. This is a Python function that Pygame Zero calls approximately 60 times per second. It should be used to tell Pygame Zero what should be displayed on the screen.

In this case the function calls screen.blit which displays a bitmap image at the appropriate position (in this case 0,0 starting at the top left of the screen).

## Creating a Sprite

A sprite is an image used in a computer game that is often created from a bitmap image. In this case there will be two sprites, one for the player (an animal character) and the other for the food (bag of animal food).

You will need several images for the sprites for the player character, so that you can show it facing different directions and to make it appear to move. The minimum needed would be an image with the character facing each of the following directions: front, right, left and rear. To make the movement a little more realistic additional images can be used with the legs moving between the images. If you are artistic then you can create your own images, but in this case I have selected some images under a creative-commons license. The example shown is a Unicorn, but it could be replaced with any appropriate animal, such as the horse images included in the download (or with a different character completely such as a car or boat).



The unicorn / horse images are from <https://opengameart.org/content/lpc-horses-rework> based on an earlier design from: <https://opengameart.org/node/69398>. The images are provided as a sprite sheet which contains all the sprites in one file. In some games the images can be used directly from the sprite sheet, but in Pygame Zero we need these as separate images. I have extracted each of the images into individual files named based on their direction and numbered 1 to 3. I have also duplicated the second image for each of these to give a total of 4 images per direction. Later you will use a bag of food, which is something I edited based on original image from Open Clipart <https://openclipart.org/detail/2413/dog-food>. For more creative commons licensed images use the search engine at: <https://search.creativecommons.org/>

To add the first image update the code as shown:

```
WIDTH = 800
HEIGHT = 600

BACKGROUND_IMG = "grass-field"

player = Actor ("unicorn-right-1")
player.pos = 150,100

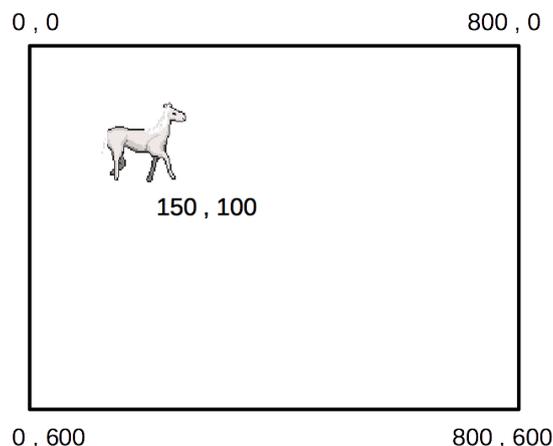
def draw():
    screen.blit(BACKGROUND_IMG, (0,0))
    player.draw()
```

The code that is shown in grey is existing code and the new lines are in black / coloured text.

In Pygame Zero a sprite is known as an actor. You can think of it as an actor on a stage (which is similar terminology that Scratch uses), although in Pygame Zero terminology it is an Actor on the screen. The actor takes an image as it's argument, following the same rules as mentioned previously when adding the background image (no path information or suffix).

The `player.pos` value is an attribute of the Actor, which determines the position of the actor on the screen. Setting this to a specific x and y position will position the actor on the screen. The first value is the x co-ordinate increasing from left to right and the second is the y co-ordinate from top to bottom.

The image below shows the co-ordinate system with the unicorn positioned at 150, 100.



## Moving the Sprite

Next you can have the sprite move around the screen. To have it move across the screen you just need to change the `player.pos` value which takes the x and y position. Or to change only one direction at a time you can use `player.x` or `player.y` as appropriate.

We could do this in the draw function used previously, but there is a separate function called the update function that is intended for these kind of updates.

First add a global variable called `delay_timer`. This should be placed before the start of the draw function.

```
# a counter to delay between changes
delay_timer = 0
```

Then add the following code at the end of the file after the draw function

```
def update():
    global delay_timer
    if (delay_timer == 10):
        delay_timer = 0
        if (player.x < 750):
            player.x += 20
    else:
        delay_timer += 1
    return
```

Like the draw function the update function is run approximately 60 times per second. That would be too quick for the character so the function has a delay factor which means that it only updates the position of the Actor every 10 times the update function is run. This is achieved by only changing the sprites position when the timer reaches 10. It then increases the x position until the x position reaches 750.

Although the image now moves across the screen it does not look particularly realistic.

This is the reason that there are multiple images. If the image is changed to one showing the legs moving each time the image is moved then the Actor moves then the player can appear to walk. This is similar to early “moving images” created using a zoetrope.



The complete code with updated images is shown below

```
WIDTH = 800
HEIGHT = 600

BACKGROUND_IMG = "grass-field"
IMG_PREFIX = "unicorn"

player = Actor (IMG_PREFIX+"-right-1")
player.pos = 150,100

# a counter to delay between changes
delay_timer = 0

# which of the 4 images to display (value from 1 to 4)
image_number = 1

def draw():
    screen.blit(BACKGROUND_IMG, (0,0))
    player.draw()

def update():
    global delay_timer, image_number
    if (delay_timer == 10):
        delay_timer = 0
        if (player.x < 750):
            player.x += 20
            image_number += 1
            if (image_number > 4):
                image_number = 1
            image_name = "{}-{}-{}".format(IMG_PREFIX,"right",image_number)
            player.image = image_name
        else:
            delay_timer += 1
            return
```

The image definition has been changed from a basic string to a prefix, direction and number. This will allow the image to be updated based on the direction and between the 4 different images for that direction.

The initial image is created using the following line:

```
player = Actor (IMG_PREFIX+"-right-1")
```

This uses the simple '+' concatenation which joins sub-strings into a single string. The image prefix variable is used which will allow you to change the selected image if you wanted to use a different character. For example if you change the earlier definition of IMG\_PREFIX to use "horse" then it will change the unicorn to a horse.

The next time the image is changed it is done using the following line, which uses the Python string formatter.

```
image_name = "{}-{}-{}".format(IMG_PREFIX,"right",image_number)
```

The string formatting uses special codes within a string to indicate where the values will be inserted. Each of the curly braces '{ }' are replaced by the appropriate argument to the format comment. The first pair of brackets is replaced with the value of IMG\_PREFIX ("unicorn"), the second by the string indicating the direction ("right") the third by the value of image\_number showing the image to be displayed (1 to 4). Which will give the same string as used previously.

This string is then used to set the `player.image` value which will replace the current image. The Actor is displayed using the `draw` function as before and but it is changed in the `update` function.

## The `draw()` vs the `update()` function

It is worth restating the purpose of the two different functions.

# Draw function – updates the screen, include draw of any actors.

```
def draw():
```

# Update function – use to handle updates to the players and check the status of the keyboard.

```
def update():
```

These functions are both called 60 times per second.

Note that the timing of the movement is only approximate. Although the update function should run 60 times every second the actual timing will depend upon a number of factors including whether the system has sufficient resources available to meet that requirement. For more details see:

<https://pygame-zero.readthedocs.io/en/stable/hooks.html#update>

## Controlling the Movement

To detect key presses on the keyboard there is a `keyboard` built-in. For each key there is an attribute which is normally `False` and then changes to `True` when that key is pressed.

The following code can be used to determine if one of the arrow keys are pressed.

```
if (keyboard.up):
    direction = "up"
if (keyboard.down):
    direction = "down"
if (keyboard.left) :
    direction = "left"
if (keyboard.right) :
    direction = "right"
```

After adding the code to move the direction, the update function should look like the following:

```
def update():
    global delay_timer, image_number
    # Only move whilst key is pressed
    if (delay_timer == 10):
        delay_timer = 0

        direction = "none"
        if (keyboard.up):
            if (player.y > 40):
                player.y -= 20
            direction = "rear"
        if (keyboard.down):
            if (player.y < 560):
                player.y += 20
```

```

        direction = "front"
    if (keyboard.left) :
        if (player.x > 40):
            player.x -= 20
            direction = "left"
    if (keyboard.right) :
        if (player.x < 760):
            player.x += 20
            direction = "right"

    if (direction != 'none'):
        image_number += 1
        if (image_number > 4):
            image_number = 1
        image_name = "{}-{}-{}".format(IMG_PREFIX,direction,image_number)
        player.image = image_name
else:
    delay_timer += 1
return

```

## Adding the food sprite

There is another image in the images directory called food.png. This will be the food that has to be collected.

It is created as a new Actor and it's location determined using a random x and y co-ordinate.

To create a random location it uses the random module which should first be imported and then uses the randint method which returns a random integer between the values given. The edge of the screen is avoided to prevent the food being partly on and partly off the screen.

```

import random

WIDTH = 800
HEIGHT = 600

BACKGROUND_IMG = "grass-field"
IMG_PREFIX = "unicorn"

player = Actor (IMG_PREFIX+"-right-1")
player.pos = 150,100

food = Actor ("food")
food.pos = (random.randint (50, 750), random.randint (50, 550))

# a counter to delay between changes
delay_timer = 0

# which of the 3 images to display (value from 1 to 3)
image_number = 1

score = 0

def draw():
    screen.blit(BACKGROUND_IMG,(0,0))
    food.draw()
    player.draw()

```

```

def update():
    global delay_timer, image_number, score
    # Only move whilst key is pressed
    if (delay_timer == 10):
        delay_timer = 0

        direction = "none"
        if (keyboard.up):
            if (player.y > 40):
                player.y -= 20
                direction = "rear"
        if (keyboard.down):
            if (player.y < 560):
                player.y += 20
                direction = "front"
        if (keyboard.left) :
            if (player.x > 40):
                player.x -= 20
                direction = "left"
        if (keyboard.right) :
            if (player.x < 760):
                player.x += 20
                direction = "right"

        if (direction != 'none'):
            image_number += 1
            if (image_number > 4):
                image_number = 1
            image_name = "{}-{}-{}".format(IMG_PREFIX,direction,image_number)
            player.image = image_name

            if (player.colliderect(food)):
                score += 1
                food.pos = (random.randint (50, 750), random.randint (50, 550))

    else:
        delay_timer += 1
        return

```

The `colliderect` method is used to detect when the player actor reaches the food actor. It detects when the rectangle containing the player actor overlaps with the rectangle containing the food actor. This is called a collision.

When a collision is detected then the score is incremented and the food is moved to a new random location.

## Timer

A game is not going to be much fun unless it poses a challenge. The challenge of this game will be of trying to get the food before the time runs out. The timer will start quite long with the timer decreasing each time the food is eaten, so as to get harder each time some food is eaten.

A new variable is created called `game_timer`. This will hold a count-down value since the last time the player ate some food. The initial count down will be set with the value from `game_timer_start`. This is set at 10 seconds. The `timer_decrement` value is the amount that the timer will decrement from the start time each time that a point is scored.

```
game_timer = 10
game_timer_start = 10
timer_decrement = 0.2
```

The value of the `game_timer` is then decremented by 0.017 seconds each update loop (which is the length of time that should pass between each time the function is called).

To make the game more challenging as each point is scored then the `game_timer` is set a little lower each time. This is done by the following formula.

```
game_timer = game_timer_start - (score * timer_decrement)
```

Remember that the timer is only approximate as there is no guarantee that the update function will run at 60 times per second.

## Display text

The final thing is to tell the player what score they achieved when the game is over.

The method to display the text is `screen.draw.text`. This needs to be within the draw function rather than update.

```
display_text = "Game Over\nScore "+str(score)

screen.draw.text(display_text, fontsize=60, center=(100,50), shadow=(1,1),
color=(255,255,255), scolor="#202020")
```

The arguments are mostly self explanatory. The color value is the colour of the text and scolor the shadow. The color is set using RGB values representing the amount of Red,Green,Blue respectively and the scolor using a string based on the hexadecimal value (similar to how colours are defined in HTML / CSS). I have deliberately used both to show that you can use either, but you can use whichever colour format you prefer.

## Complete code

The code for the complete game is shown below:

```
import random

WIDTH = 800
HEIGHT = 600

BACKGROUND_IMG = "grass-field"
IMG_PREFIX = "unicorn"

player = Actor (IMG_PREFIX+"-right-1")
player.pos = 150,100

food = Actor ("food")
food.pos = (random.randint (50, 750), random.randint (50, 550))

# a counter to delay between changes
delay_timer = 0

# The game timer to restrict how long the player has to collect food
```

```

game_timer = 10
game_timer_start = 10
timer_decrement = 0.2

# which of the 3 images to display (value from 1 to 3)
image_number = 1

score = 0

def draw():
    screen.blit(BACKGROUND_IMG, (0,0))
    if (game_timer <= 0):
        display_text = "Game Over\nScore "+str(score)
        screen.draw.text(display_text, fontsize=60, center=(400,300),
shadow=(1,1), color=(255,255,255), scolor="#202020")
    food.draw()
    player.draw()

def update():
    global delay_timer, image_number, score, game_timer
    if (game_timer <= 0):
        return
    else:
        game_timer -= 0.017

    # Only move whilst key is pressed
    if (delay_timer == 10):
        delay_timer = 0

        direction = "none"
        if (keyboard.up):
            if (player.y > 40):
                player.y -= 20
                direction = "rear"
        if (keyboard.down):
            if (player.y < 560):
                player.y += 20
                direction = "front"
        if (keyboard.left) :
            if (player.x > 40):
                player.x -= 20
                direction = "left"
        if (keyboard.right) :
            if (player.x < 760):
                player.x += 20
                direction = "right"

        if (direction != 'none'):
            image_number += 1
            if (image_number > 4):
                image_number = 1
            image_name = "{}-{}-{}".format(IMG_PREFIX,direction,image_number)
            player.image = image_name

            if (player.colliderect(food)):
                score += 1
                food.pos = (random.randint (50, 750), random.randint (50, 550))
                game_timer = game_timer_start - (score * timer_decrement)

    else:
        delay_timer += 1
        return

```

## Future Improvements

You now have the starting point of a game, but it's only the start of the process of creating a game.

Here is a list of possible suggestions to improve the game, with hints on how they can be achieved:

- Show the score on the screen as each point is scored.
  - Use `screen.draw.text()` to display score at the top of the screen.
- Add a countdown timer to the screen.
  - Display the `game_timer` on the screen. Note that the value may need to be adjusted so that the game ends as soon as the display of the game timer reaches 0.
- Add obstacles that need to be avoided.
  - Create new actors with the obstacles and test for collisions with the obstacles.
- Allow the player to play again after the end of the game.
  - Wrap the entire game into a while loop with an option to play again after the player has finished the game.
- Add tracking of a high score to provide additional challenge.
  - To allow the high score to persist in new games it should be saved.

These suggestions and others have already been implemented in a similar game known as Compass Game which is available from <http://www.penguintutor.com/projects/compass-game> The Compass Game is a different game, but shares much of the same initial code. It has however changed considerably converting much of the code to object orientated code and adding new features.

Another option is to change the game by changing the sprites and perhaps the gameplay. The previously mentioned Compass Game is similar in that regard. Instead of trying to reach food in Compass Game the player has to go in the direction specified. It is possible to change the character to a completely different creature, vehicle or even a space craft.

## Updates and Other Projects

For a related project see the Space Asteroids game from the 2018 Raspberry Pi Birthday. This game uses Pygame Zero and GPIO Zero <http://www.penguintutor.com/projects/space-asteroids>

For future updates on this and other projects follow PenguinTutor on Twitter, Facebook or YouTube.