OOP in Arcade

Videogames Technology
Asignatura transversal

Departamento de Automática

Universidad de Alcalá

Objectives

1. Understand the OO API in Arcade
2. Use sprites and sprites sheets with Arcade
3. Handle user input (mouse, keyboard and joysticks)
4. Understand some multimedia file formats
5. Introduce the `Window`, `View` and `Sprite` classes

Bibliography

1. Paul Craven. *Drawing & Using Sprites*. (link).
2. Paul Craven. *Keyboard*. (link).
3. Paul Craven. *Textures*. (link).
4. Paul Craven. *Using Views for Start/End Screens*. (link).

Table of Contents

The Window class

Introduction

Arcade has an OOP API

- More features than structured API
- Easy to use API

This API is based on the `arcade.Window` class

```
1  import arcade
2
3
4  def main():
5      window = arcade.Window(640, 480, "Example")
6
7      arcade.run()
8
9
10 main()
```

The Window class

Extending the Window class

```
1  import arcade
2
3
4  class MyGame(arcade.Window):
5
6      def __init__(self, width, height, title):
7
8          # Call the parent class's init function
9          super().__init__(width, height, title)
10
11
12 def main():
13     window = MyGame(640, 480, "Drawing Example")
14
15     arcade.run()
16
17
18 main()
```

The Window class

Main methods and attributes

arcade.Window

Methods

- `on_draw()`.
  Drawing
- `on_update(delta_time: float)`.
  Move everything. Perform collision checks.
  Do all the game logic here
- `clear()`.
  Clear screen
- `set_background_color(color)`.
  Set color used by `clear()`

Attributes

- `background_color`
  Color used by `clear()`

Ball

```
import arcade


class MyGame(arcade.Window):
    def __init__(self, width, height, title):
        # Call the parent class's init function
        super().__init__(width, height, title)

        # Set the background color
        #arcade.set_background_color(arcade.color.ASH_GREY)
        self.background_color = arcade.color.ASH_GREY

    def on_draw(self):
        """ Called whenever we need to draw the window. """
        self.clear()

        arcade.draw_circle_filled(50, 50, 15, arcade.color.AUBURN)

def main():
    window = MyGame(640, 480, "Drawing Example")

    arcade.run()

main()
```

Animated ball

```
1  import arcade
2
3  class MyGame(arcade.Window):
4
5      def __init__(self, width, height, title):
6          super().__init__(width, height, title)
7
8          arcade.set_background_color(arcade.color.ASH_GREY)
9
10         self.ball_x = 50
11         self.ball_y = 50
12
13     def on_draw(self):
14         """ Called whenever we need to draw the window. """
15         self.clear()
16
17         arcade.draw_circle_filled(self.ball_x, self.ball_y, 15,
           ↪  arcade.color.AUBURN)
18
19     def on_update(self, delta_time):
20         """ Called to update our objects."""
21         self.ball_x += 1
22         self.ball_y += 1
23
```

It violates encapsulation, (link to better solution)

The Window class

Constructor

Constructor

```
1  class arcade.Window(
2          width: int = 1280,
3          height: int = 720,
4          title: Optional[str] = 'Arcade Window',
5          fullscreen: bool = False,
6          resizable: bool = False,
7          center_window: bool = False,
8          draw_rate: Optional[float] = 0.016666666666666666,
9          update_rate: Optional[float] = 0.016666666666666666)
```

Remember to use reference documentation

- (`arcade.Window` reference)

$$\frac{1}{0{,}016666666666666666} = 60\text{Hz}$$

The Window class

Other methods

Other methods

- activate()
- center_window()
- close()
- get_location()
- get_size()
- maximize() and minimize()
- set_fullscreen(fullscreen: bool = True)
- set_location(x, y)

Adding a setup() method is recommended

User control

Introduction

How does the player interact with the game?

- Mouse
- Keyboard
- Game controller (joystick or gamepad)

The key is to override Window methods

User control

Mouse (I)

Overriding the following `arcade.Window` methods

- `on_mouse_motion(x, y, delta_x, delta_y)`.
  Called whenever the mouse moves.
- `on_mouse_press(x: float, y: float, button: int, modifiers: int)`.
  Called when the user presses a mouse button.
- `on_mouse_release(x: float, y: float, button: int, modifiers: int)`.
  Called when the user releases a mouse button.

Make the mouse pointer dissapear:

- Call `self.set_mouse_visible(False)` the constructor

User control

Mouse (II)

Capturing a mouse click

```
1  def on_mouse_press(self, x, y, button, modifiers):
2      """ Called when the user presses a mouse button. """
3
4      if button == arcade.MOUSE_BUTTON_LEFT:
5          print("Left mouse button pressed at", x, y)
6      elif button == arcade.MOUSE_BUTTON_RIGHT:
7          print("Right mouse button pressed at", x, y)
```

Moving a ball with a mouse

(Example)

(More info about keys)

User control

Keyboard

Two **events** when we press a key

- Press and release

Overriding the following `arcade.Window` methods

- `on_key_press(symbol: int, modifiers: int)`
  Called when the user presses key.
- `on_key_release(symbol: int, modifiers: int).`
  Called when the user releases key.

Capturing a key

```
1  def on_key_press(self, key, modifiers):
2      if key == arcade.key.LEFT:
3          print("Left key hit")
4      elif key == arcade.key.A:
5          print("The 'a' key was hit")
```

(Example)

User control

Game controller (I)

A computer might not have any controller, or it might five game controllers

- `arcade.get_joysticks() -> list(Joystick)`

Init controller in `__init__`

```
1  joysticks = arcade.get_joysticks()
2
3  if joysticks:
4      self.joystick = joysticks[0]
5      self.joystick.open()
6  else:
7      print("There are no joysticks.")
8      self.joystick = None
```

User control

Game controller (II)

Read game controller value

```
1  def update(self, delta_time):
2      # Update the position according to the game controller
3      if self.joystick:
4          print(self.joystick.x, self.joystick.y)
```

Centered $(0, 0)$

Down $(0, 1)$

Up $(0, -1)$

Down-left $(-1, 1)$

(Source)

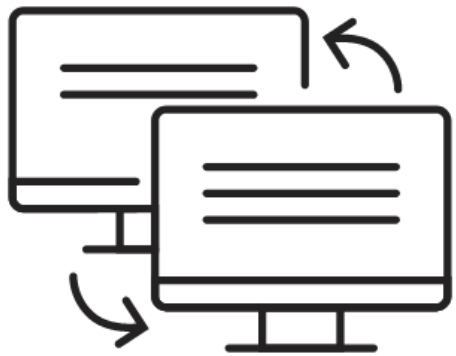
(Interesting example - Arcade 2.6.17)

The `View` class (I)

The need for views

Videogames use to show several screens

- Start screens
- Instruction screens
- Game over screens
- Pause screens



(Source)

Arcade provides the `View` class

- Very much like the Window class
- It has the `on_draw()` and `on_update()` methods

The View class

The View class (II)

Our class must inherit from `arcade.View`

```
class MyGame(arcade.Window):
```

⇒

```
class GameView(arcade.View):
```

The view does not control the window size, so

```
super().__init__(WIDTH, HEIGHT, TITLE)
```

⇒

```
super().__init__()
```

The mouse pointer is still controlled by the window, so

```
self.set_mouse_visible(False)
```

⇒

```
self.window.set_mouse_visible(False)
```

The View class

The View class (III)

Finally, we need to create a window, a view and show that view

```
1  def main():
2      """ Main function """
3
4      window = arcade.Window(WIDTH, HEIGHT, TITLE)
5      start_view = GameView()
6      window.show_view(start_view)
7      start_view.setup()
8      arcade.run()
```

The View class

Changing views

We can switch the view any time

- `show_view(view: View)`

`on_view_draw()`

- Run once when we switch to the view

From a view

```
1  def on_update(self, delta_time):
2
3    [...]
4
5    if len(self.coin_list) == 0:
6      view = GameOverView()
7      self.window.show_view(view)
```

The `View` class

Example: Game Over screen

GameOverView view

```
1  class GameOverView(arcade.View):
2      """ View to show when game is over """
3
4      def __init__(self):
5          """ This is run once when we switch to this view """
6          super().__init__()
7          self.texture = arcade.load_texture("game_over.png")
8
9      def on_draw(self):
10         """ Draw this view """
11         self.clear()
12         self.texture.draw_sized(WIDTH / 2, HEIGHT / 2, WIDTH, HEIGHT)
13
14     def on_mouse_press(self, _x, _y, _button, _modifiers):
15         """ If the user presses the mouse button, re-start the game. """
16         game_view = GameView()
17         game_view.setup()
18         self.window.show_view(game_view)
```

(Starting template)

The View class

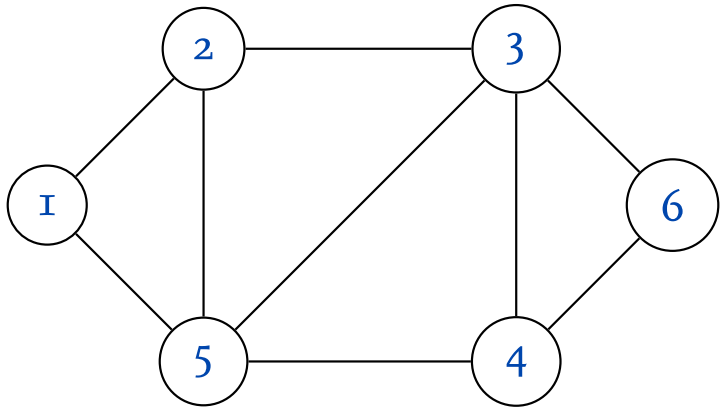
Graphs

Graph: Data structure with **nodes** and **edges**

- Widely used in programming, AI and videogames
- Huge number of applications

Central role in path planning

- (Video)
- Navigation mesh

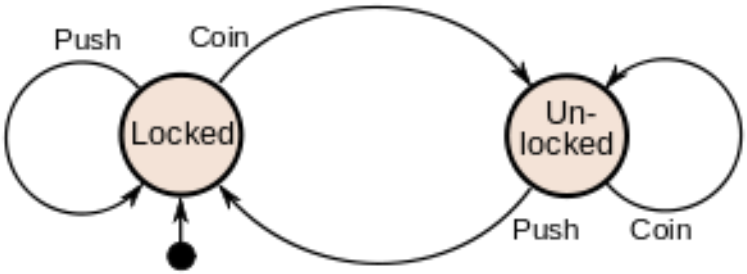


The `View` class

Finite States Machines (I)

Finite-State Machine (FSM)

A graph whose nodes represent states, usually associated with behaviours



(Source)

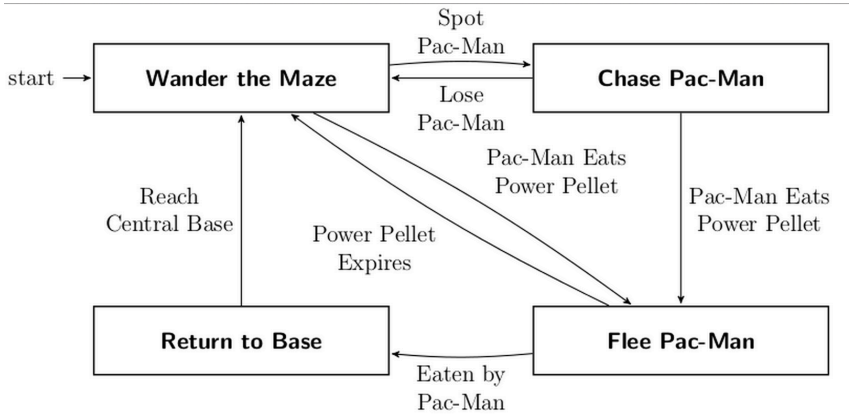
The View class

Finite States Machines (II)

FSMs have many applications

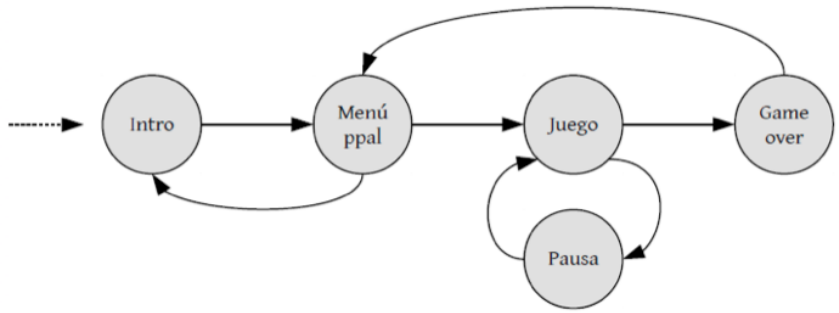
- Central role in Theory of Computation
- Good to model behaviours ... such as a NPC or an entire videogame

NPC behaviour



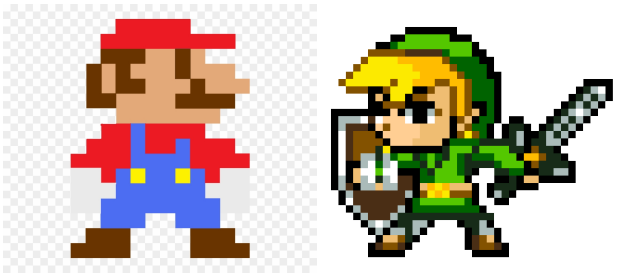
(Source)

Game life-cycle



The Texture class

Introduction



In Arcade, images are named **textures**

- Implemented by the `arcade.Texture` class

Two texture loading methods

- `arcade.load_texture()`
- `arcade.Texture()`

Functional

```
mario = arcade.load_texture("mario.png")
mario = arcade.load_texture(Path("mario.png"))
```

Object-oriented

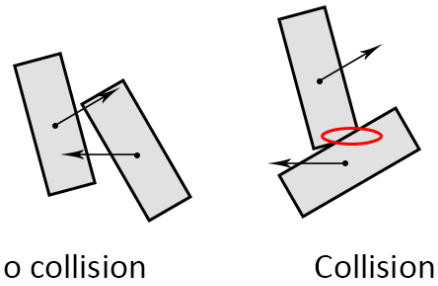
```
mario = arcade.Texture("mario.png")
mario = arcade.Texture(Path("mario.png"))
```

The Texture class

Hitboxes

The Texture class provides

- Hitbox geometry, used in collision detection
- Caching



(Source)

The Texture class

Data formats (I)

In genenal, any data can be stored in three forms

- Not compressed
- Compressed with loss
- Compressed without loss

	Image format	Sound format	Binary data
Not compressed	BMP	WAV	
Compressed with loss	JPG	MP3	
Compressed without loss	PNG, GIF	-	ZIP, bzip, rar, ...

The Texture class

Data formats (II)

Attending to what information is stored in image format, there are two types of image formats:

- Bitmap: stores each pixel
  - Scales bad
  - Formats: JPG, PNG, BMP, GIF
- Vectorial: stores coordinates
  - Scales well
  - Not supported by Arcade
  - Formats: SVG, EPS

Many open assets for your games!

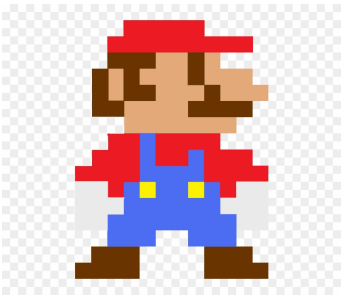
- (Kenney)

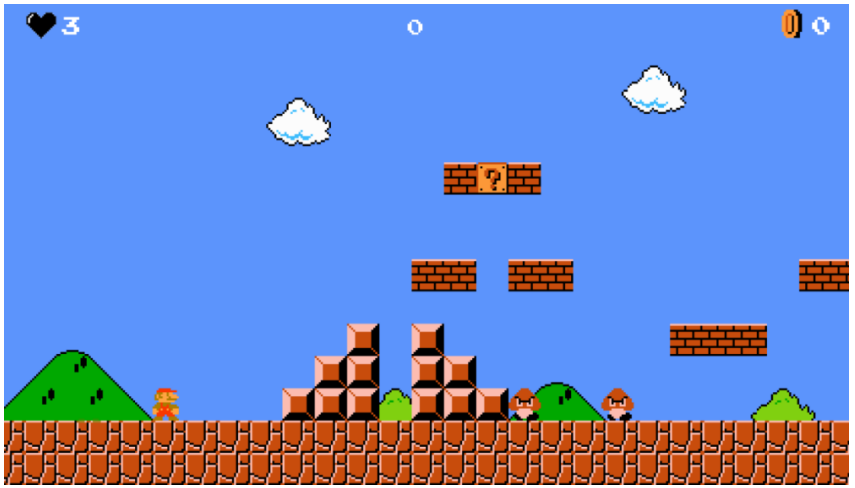
The Sprite class

Introduction

Sprite

A sprite is a 2D image used in videogames





The Sprite class

Sprites in Arcade

In Arcade, a sprite contains ...

- One or more textures
- Texture size
- Image data
- Collision detection

Acts as a base class for (our) derived classes

Implemented in the `arcade.Sprite` class

```
luigi = arcade.Sprite('luigi.png')
mario = arcade.Sprite(Path('mario.png'))
```

Inherits from `arcade.BasicSprite`

The Sprite class

Constructor

Constructor

```
1  class arcade.Sprite(
2     path_or_texture: str | Path | bytes | Texture | None = None,
3     scale: float | tuple[float | int, float | int] | Vec2 = 1.0,
4     center_x: float = 0.0,
5     center_y: float = 0.0,
6     angle: float = 0.0,
7     **kwargs: Any)
```

(Reference documentation)

The `Sprite` class

Methods and attributes (I)

`arcade.Sprite`

Methods

- `update(delta_time: float = 0.016)`
- `append_texture(texture: Texture)`
- `set_texture(texture_no: int)`
- `update(delta_time: float = 0.016)`
- `stop()`
- `kill()`
- `draw_hit_box()`

Attributes

- center_x: float and center_y: float. Center of the sprite
- change_x: float and change_y: float. Velocity in X and Y
- texture: Texture
- textures: list[Texture]
- alpha: int [0-255]
- angle: float
- scale: tuple
- bottom: float and top: float
- left: float and right: float
- visible: bool

The Sprite class

Methods and attributes (II)

Placing a sprite

```
mario.center_x = 300
mario.center_y = 200
```

Moving a sprite

```
mario.change_x = 10
mario.change_y = 1
```

Chaging visibility

```
1  # Make the sprite invisible
2  mario.visible = False
3
4  # Change back to visible
5  mario.visible = True
6
7  # Toggle visible
8  mario.visible = not sprite.visible
```

```python
class Explosion(arcade.Sprite):
    """ This class creates an explosion animation """

    def __init__(self, texture_list):
        super().__init__(texture_list[0])
        # How long the explosion has been around.
        self.time_elapsed = 0

        # Start at the first frame
        self.current_texture = 0
        self.textures = texture_list

    def update(self, delta_time=1 / 60):
        self.time_elapsed += delta_time
        # Update to the next frame of the animation.
        # If we are at the end of our frames, then delete this sprite.
        self.current_texture = int(self.time_elapsed * 60)
        if self.current_texture < len(self.textures):
            self.set_texture(self.current_texture)

        else:
            self.remove_from_sprite_lists()
```

(Complete example in python -m arcade.examples.sprite_explosion_bitmapped)

The Sprite class

Collision detection

Methods in `arcade.Sprite` to detect collisions

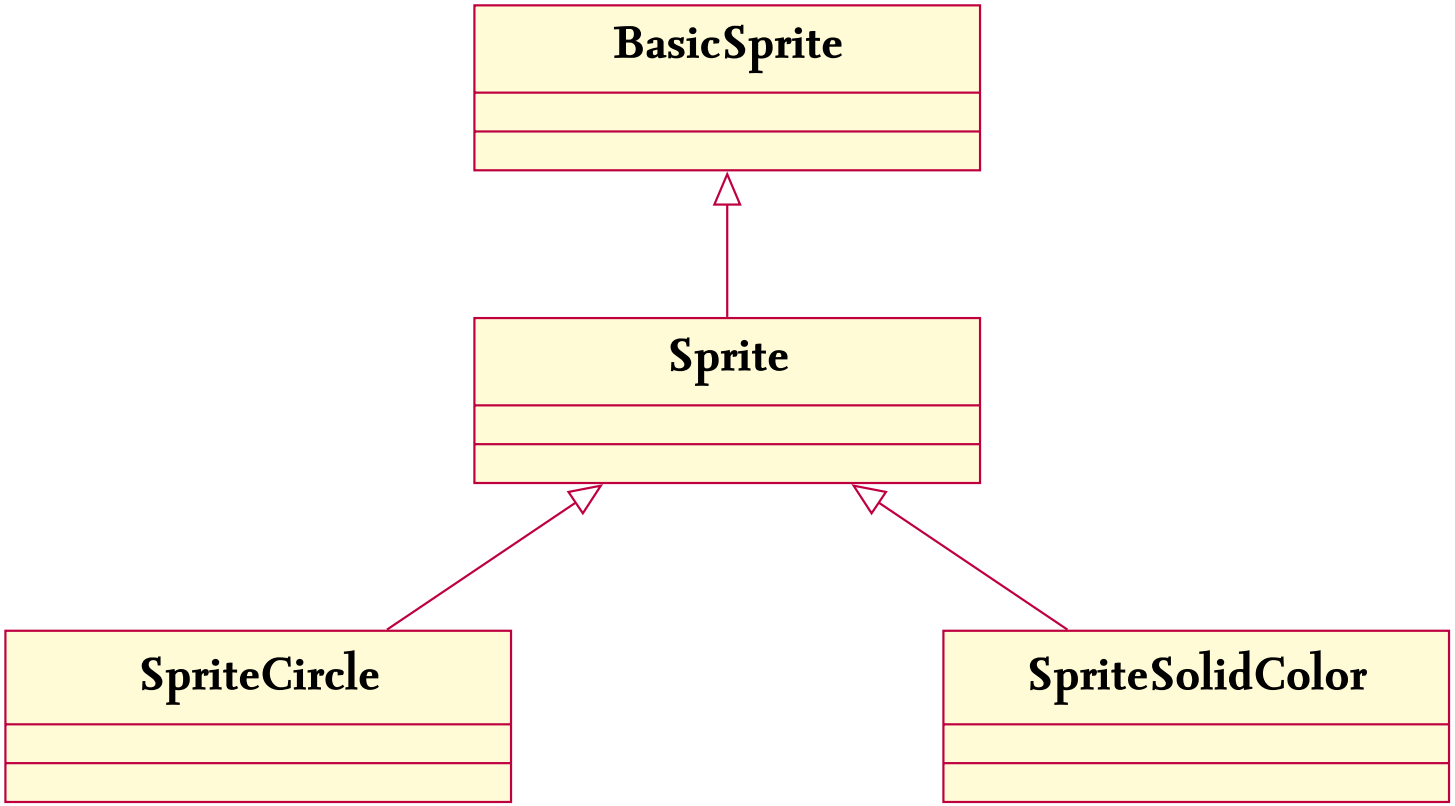
- `collides_with_list(sprite_list: SpriteList)` → `list(SpriteType)`
- `collides_with_point(point: Union[Tuple[float, float], List[float]])` → `bool`
- `collides_with_sprite(point: BasicSprite)` → `bool`
- `draw_hit_box()`

Functions in Arcade to detect collisions

- `arcade.check_for_collision(sprite1: BasicSprite, sprite2: BasicSprite)` → `bool`
- `arcade.check_for_collision_with_list(sprite: BasicSprite, sprite_list: SpriteList)` → `bool`

The Sprite class

Class hierarchy



- (SpriteCircle documentation)
- (SpriteSolidColor documentation)

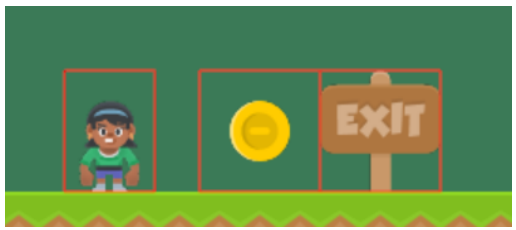
Sprite lists

Motivation

Arcade heavily uses **sprite lists**

- Batch drawing (GPU optimization)
- Collision detection
- Debug drawing for hit boxes

```
1 for sprite in sprites:
2     sprite.draw() # Not in 3.X
3
4 sprite_list.draw()
```



Sprite lists

Drawing with sprite lists

Drawing with sprite lists

1. Create a `SpriteList`
2. Create and append `Sprite` instances
3. Call `draw()`

```
wall_list = arcade.SpriteList()
```

```
wall = arcade.Sprite('boxCrate.png')
wall.center_x = 300
wall.center_y = 300

wall_list.append(wall)
```

```
wall_list.draw()
```

Sprite lists

Collision detection

Sprites can be removed from a list

```
wall.remove_from_sprite_lists()
```

Lists in Arcade also implement collision detection

```
hit_list = arcade.check_for_collision_with_list(player_sprite,
coin_list)
```

Complete example in (python -m arcade.examples.sprite_minimal)

Resources management

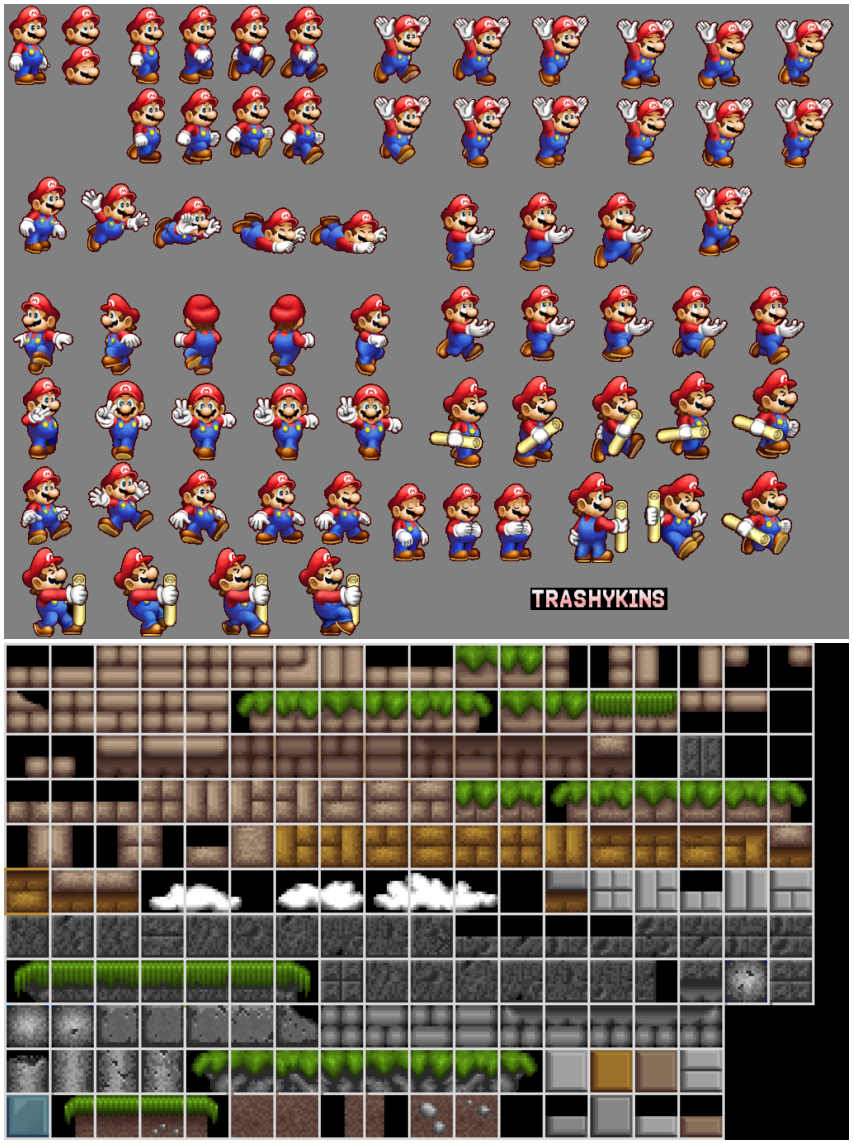
Spritesheets (I)

A videogame contains many sprites

- Difficult maintenance
- Solution: Spritesheets

Advantages

- One file contains many sprites
- Less I/O operations $\Rightarrow$ Better performance
- Less memory consumption

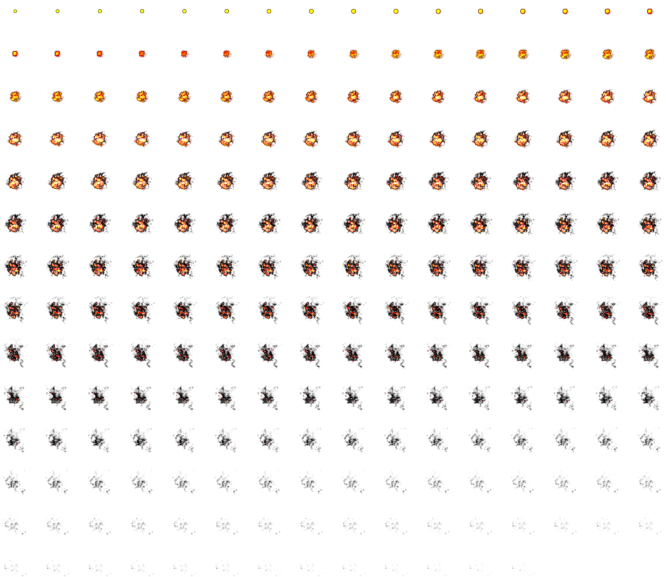


Resources management

Spritesheets (II)

Arcade provides the `arcade.SpriteSheet` class

- Gets sprites from a spritesheet



Resources management

Tile maps

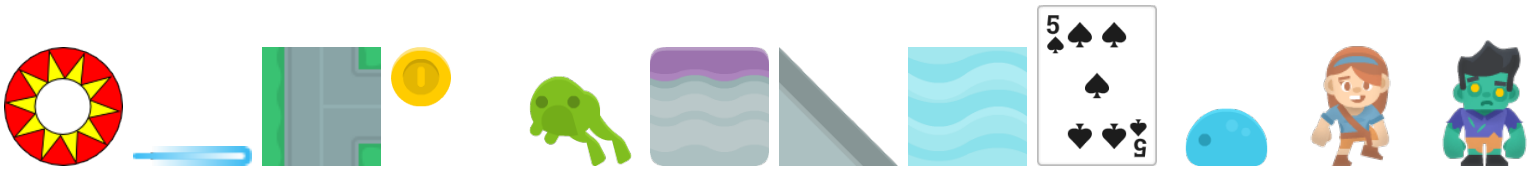
Locating sprites in the game is a tought work

- Closely related to level design
- There are tools that ease this task
- Stores maps as JSON files
- Supported by `arcade.TileMap`

(Tiled Map Editor)

Resources management

Resources handlers



Arcade comes along a collection of built-in resources

- Good for testing
- No need of files in the project

The path is something like `':resources:/path/to/resource'`

```
arcade.Sprite(":resources:images/items/coinGold.png")
```

Resources management

Built-in resources

Type of built-in resources

- Images (characters, backgrounds, etc)
- Sounds and music
- Fonts
- GUI basic assets (such as bottons and checkboxes)
- Tile maps

(List of resources)
(Source code)