10 Programming with Sound

Literature:

W. McGugan, Beginning Game Development with Python and Pygame, Apress 2007

Example: Background Music

- How to play back music while the program runs?
  - How to access the sound subsystem?
  - How to load a sound file?
    - » Supported file formats?
  - How to control playback?
- Sound playback always takes place ***in parallel*** to rest of program
  - Separate *thread* in program
  - Time container in *parallel* composition

Example: Background Music (1)

```
import pygame
from pygame.locals import *
from sys import exit

background = pygame.Color(255, 228, 95, 0)
sc_w = 356
sc_h = 356
music_file = "nancygroff_turntome.ogg"

pygame.init()
pygame.mixer.init(44100, -16, 2, 1024*4)

# Create program display area
screen = pygame.display.set_mode((sc_w, sc_h), 0, 32)
pygame.display.set_caption("Simple Slide Show")

# Set background color
screen.fill(background)

     ...contd.
```

Sound Initialization

- Sound subsystem:
  - Gateway between program and operating system
    - Abstraction layer (e.g. Pygame)
    - Possibly plus system-specific plug-ins
  - *Mixer* (name derived from audio mixer hardware)
- Audio Format:
  - Sample rate / playback rate: samples/second
  - Sample size: bits
  - Stereo channels (mono=1, stereo=2)
  - Buffer size: number of samples buffered for playback
    - Relatively low-level interface in Pygame
- Pygame mixer initialization defines playback properties:

  ```
  pygame.mixer.init(44100, -16, 2, 1024*4)
  ```

  44100 samples/s, 16 bit samples (signed), stereo, 4k buffer

Example: Background Music (2)

UPDATE

```
...(cont.)

# Load and play background music
pygame.mixer.music.load(music_file)
pygame.mixer.music.play()

# Load slide and show it on the screen
slide = pygame.image.load('pics/tiger.jpg').convert()
screen.blit(slide,(50, 50))
pygame.display.update()
pygame.time.wait(4000)
...
# Load slide and show it on the screen
slide = pygame.image.load('pics/
  butterfly.jpg').convert()
...
pygame.time.wait(4000)
pygame.mixer.music.fadeout(3000)
```

mixer.music:
Special interface for long-running background sound

Program Control of Sound Playback

- Main functions (of **`mixer`** object):

`load():`	Loads a new sound from given filename
`play():`	Starts playback
`pause():`	Stops playback, ready for continuation
`unpause():`	Continues paused playback
`stop():`	Stops playback, no continuation possible

- Other functions realizable by combination
  - E.g. "restart" by combination of "stop" and "play"

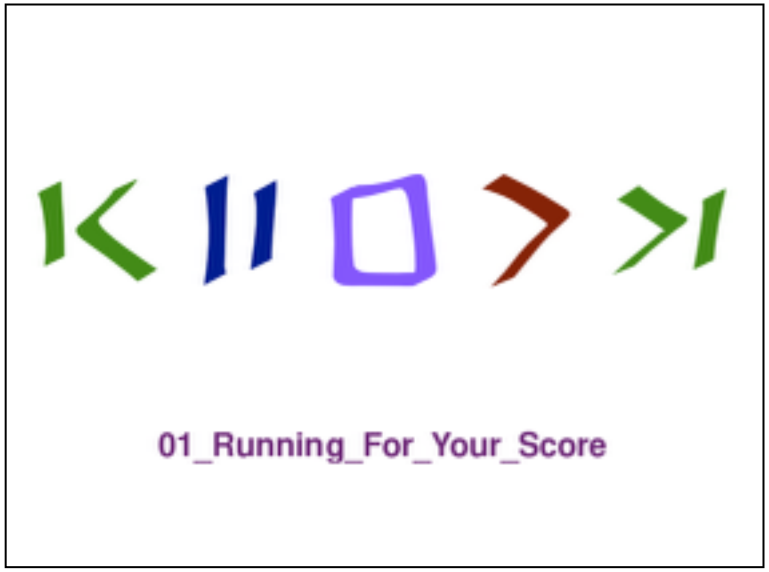
- Example: Jukebox
  - Scans directory for sound files
  - Builds list of sound files
  - Interactive interface for skipping through files and playback

Example: Jukebox (1)

```
def get_music(path):
    raw_filenames = os.listdir(path)
    music_files = []
    for filename in raw_filenames:
      music_files.append(
           os.path.join(MUSIC_PATH, filename))
    return sorted(music_files)
...
music_filenames = get_music(MUSIC_PATH)
current_track = 0
max_tracks = len(music_filenames)
pygame.mixer.music.load(
    music_filenames[current_track] )
clock = pygame.time.Clock()
playing = False
paused = False
```

Example: Jukebox (2)

```
...
 if button_pressed == "next":
   current_track =
      (current_track + 1) % max_tracks
   pygame.mixer.music.load(
      music_filenames[current_track] )
   if playing:
      pygame.mixer.music.play()
 elif button_pressed == "prev":
   if pygame.mixer.music.get_pos() > 3000:
      pygame.mixer.music.stop()
      pygame.mixer.music.play()
   else:
      current_track = (current_track - 1) % max_tracks
      pygame.mixer.music.load(
         music_filenames[current_track] )
      if playing:
         pygame.mixer.music.play()
 elif button_pressed == "pause":
   if paused:
      pygame.mixer.music.unpause()
      paused = False
   else:
      pygame.mixer.music.pause()
```



Across-Platform Concepts

- Background sound vs. short audio clips
  - Background sound not loaded into working memory completely (e.g. sound.music in Pygame, Media in JavaFX)
  - Streaming for background sound
- Loading sound from file
  - Pre-loading process
  - Format and sub-system dependencies
- Determining runtime characteristics for sound
  - E.g. default volume
- Sound rendering
- Runtime control for sound
  - Playback control (play, pause etc.) through *handler* object (mixer in Pygame, MediaPlayer in JavaFX)
  - Dynamic rendering control (e.g. volume)
    - » only for long-running sounds

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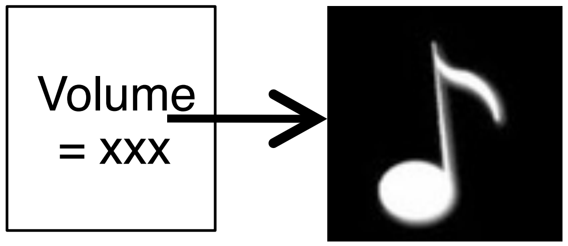
Rendering Control Objects

- Rendering process can be modified by parameter settings:
  - For images: e.g. compositing rules, clipping
  - For sound: e.g. volume, placement of mono source in stereo panorama
- Specific object representing rendering parameters: *rendering control*
  - Refers to media object (is a *handle* on the object)
  - Locally stores rendering parameters
  - May refer to individual channels, input to mixer
  - May refer to global sound, output of mixer
- Examples:
  - *Channel* objects in Pygame
  - *MediaPlayer* object in JavaFX



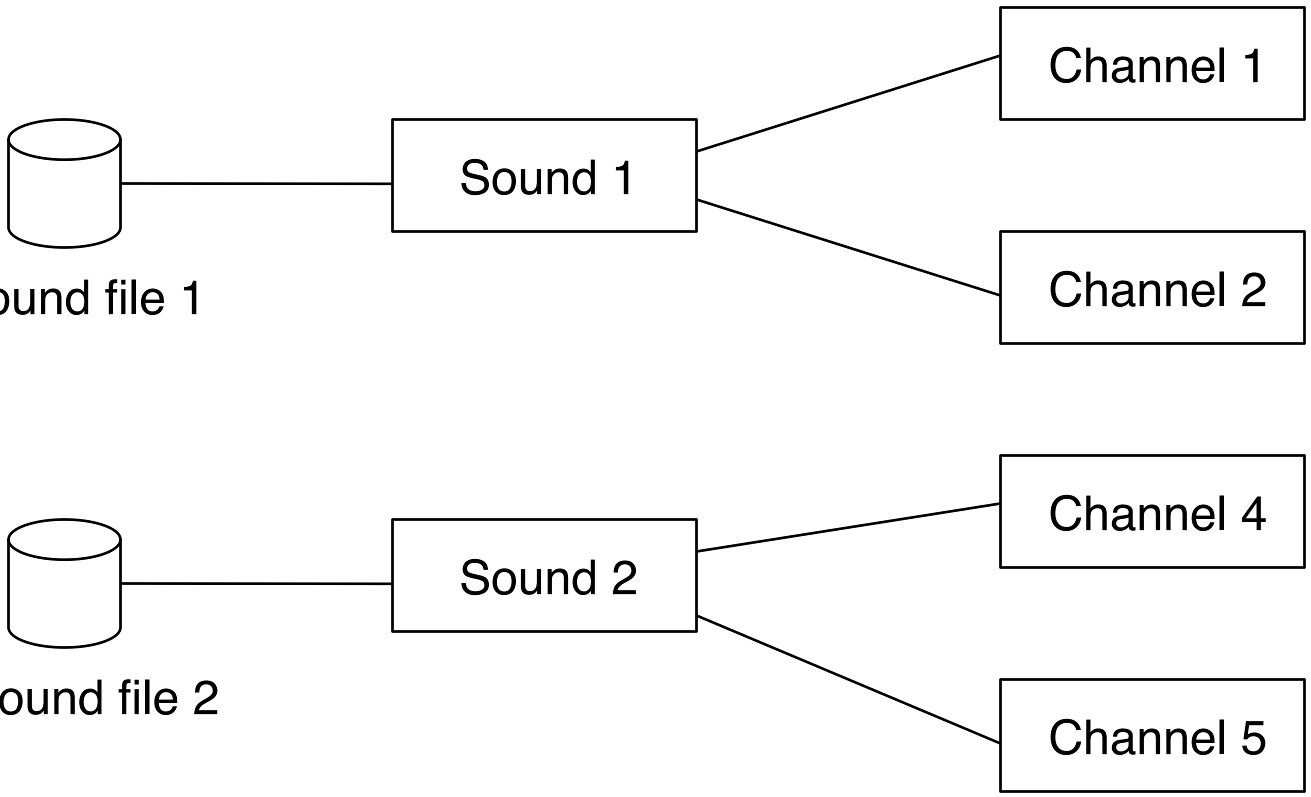
Panorama and Balance

- Balance:
  - Adjustment of relative level of stereo channels (attenuation)
  - Mainly for adapting to suboptimal speaker position
- Panorama (Pan):
  - Placing a sound source in the stereo panorama
  - Distribution of the signal over left/right channel
  - Mainly applied for mixing a monaural signal into a stereo signal
  - Can also be applied to stereo signals
- Both names often used interchangeably
- Typical parameter coding:
  - Either float value between 0.0 and 1.0
  - Or float value between –1.0 and +1.0 (where 0.0 means center)

Channels in Pygame

- Channel:
  - One out of several sources that are mixed together by the sound card
  - **`play()`** method returns a Channel object (or **`None`** if all channels are busy)
- Limited number of channels
  - Number of channels can be set (**`pygame.mixer.set_num_channels`**)
  - Channels are assigned to playing tasks automatically until maximum number is reached (all channels busy)
  - Channels for important audio information can be reserved (**`pygame.mixer.set_reserved`**)
- Typical methods for Channel objects:
  - Individual playback control (pause, play)
  - Volume control, for left and right speakers
  - Event handling for end of playing time
    - » Fire event at end of playing time
    - » Play queued sound object

Multiple Sounds and Channels



Asynchronous Playback (QUIZ!)

- ***Quiz*** question:
  What do we hear when this code is executed?

```
sound1 = pygame.mixer.Sound(soundfile)
channel1 = sound1.play()
channel2 = sound1.play()
channel3 = sound1.play()
```

- The play() method triggers the start of playback only...

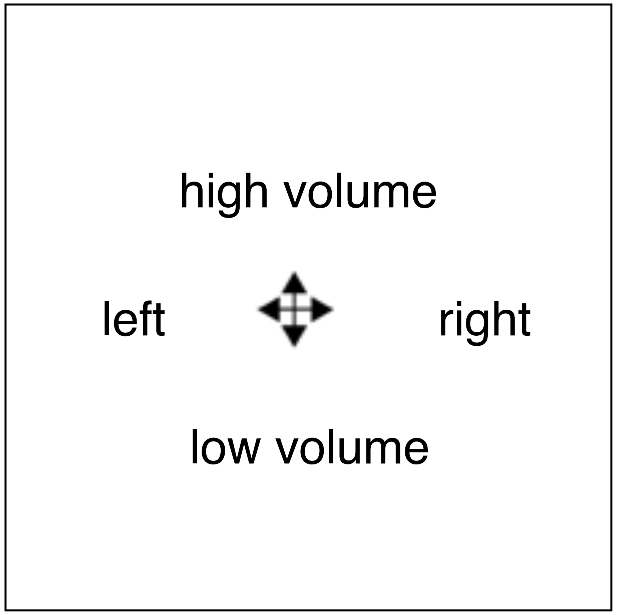
Setting Volume/Pan with Mouse (1)

```
SCREEN_SIZE = (480, 480)
cursor_image_file = "arrowcursor.png"
loop_file = "GuitarLoop.wav"

import pygame
from pygame.locals import *

pygame.mixer.init(44100, -16, 2, 1024*4)
pygame.init

screen = pygame.display.set_mode(SCREEN_SIZE, 0)
pygame.display.set_caption("Sound Control")
mouse_cursor =
  pygame.image.load(cursor_image_file).convert_alpha()

loop_sound = pygame.mixer.Sound(loop_file)
channel = loop_sound.play(-1)

...contd.
```

Setting Volume/Pan with Mouse (2)

```
...
  xPos = max(0, float(mouseX)/SCREEN_SIZE[0])
  yPos = max(0, float(mouseY)/SCREEN_SIZE[1])
  vol = 1.0-yPos
  pan = xPos
  channel.set_volume(vol*(1.0-pan), vol*pan)
```

...contd.



Setting Volume/Pan with Mouse (3)

```
...

while True:
      for event in pygame.event.get():
            if event.type == QUIT:
                exit()
            screen.fill((255, 255, 255))
            mouseX, mouseY = pygame.mouse.get_pos()
            cursorX = mouseX - mouse_cursor.get_width()/2
            cursorY = mouseY - mouse_cursor.get_height()/2
            screen.blit(mouse_cursor, (cursorX, cursorY))
            pygame.display.update()

            if channel is not None:
                compute xpos, ypos and adjust volume/pan
```

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Event-Driven Sound

- In interactive programs and animations:
  - Sound as part of presentation
  - Needs to be synchronised with user interactions and animation progress
  - Several sounds may play synchronously
- Examples:
  - Sound triggered by collision detection in animation (bounce, crash)
  - Sound triggered by user input (keyboard beep)
  - Sound synchronised with animation (pitch or volume analog to movement)
- Sound triggering events may be explicit program events or just implicit (position in program code)

Events Created by Sound System

- Specific conditions of the sound system may be made available as events to the programmer
  - Example: “End event” for playback in Pygame

    `Channel.set_endevent(id)`
    requests an event to be triggered when sound has finished playing. Appropriate identifier for event is given as parameter
- Examples for other events possibly created by sound system (*not* Pygame-specific):
  - External change of volume or other parameters
  - Playback reaching a certain intermediate position *(cue point)*
  - Exceptional situations (e.g. too few channels)

Example: Bouncing Balls (1)

From Pygame book (excerpt):

```
class Ball(object):

    def __init__(self, position, speed, image, bounce_sound):

        self.position = Vector2(position)
        self.speed = Vector2(speed)
        self.image = image
        self.bounce_sound = bounce_sound
        self.age = 0.0

    def update(self, time_passed):

        w, h = self.image.get_size()

        screen_width, screen_height = SCREEN_SIZE

        x, y = self.position
        x -= w/2
        y -= h/2
        ...
```

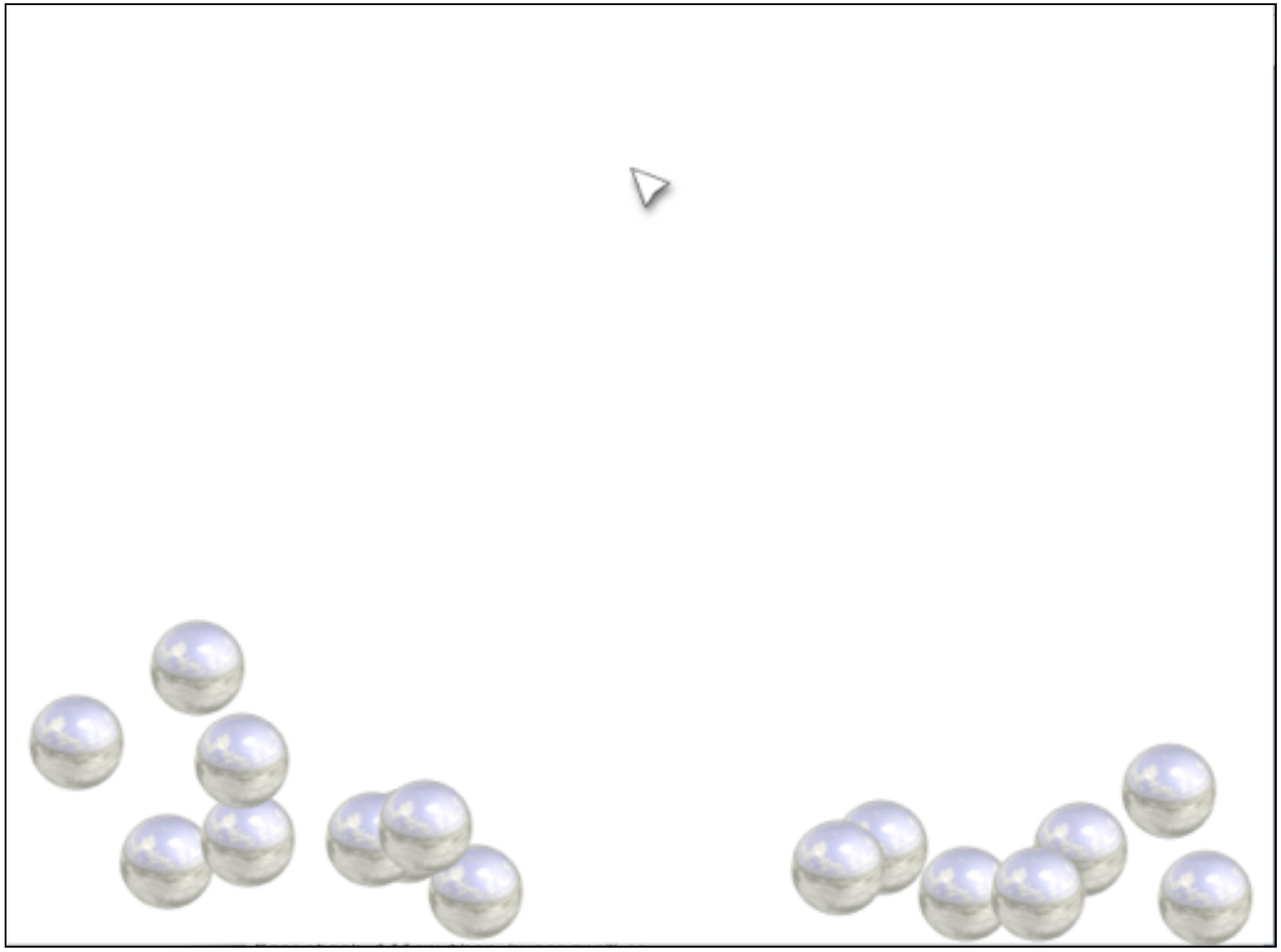
Example: Bouncing Balls (2)

```
(update contd.)

# Has the ball bounced?
bounce = False

# Has the ball hit the bottom of the screen?
if y + h >= screen_height:
    self.speed.y = -self.speed.y * BOUNCINESS
    self.position.y = screen_height - h / 2.0 - 1.0
    bounce = True

# Has the ball hit the left of the screen?
if x <= 0:
    self.speed.x = -self.speed.x * BOUNCINESS
    self.position.x = w / 2.0 + 1
    bounce = True

# Has the ball hit the right of the screen
elif x + w >= screen_width:
    self.speed.x = -self.speed.x * BOUNCINESS
    self.position.x = screen_width - w / 2.0 - 1
    bounce = True
...
```

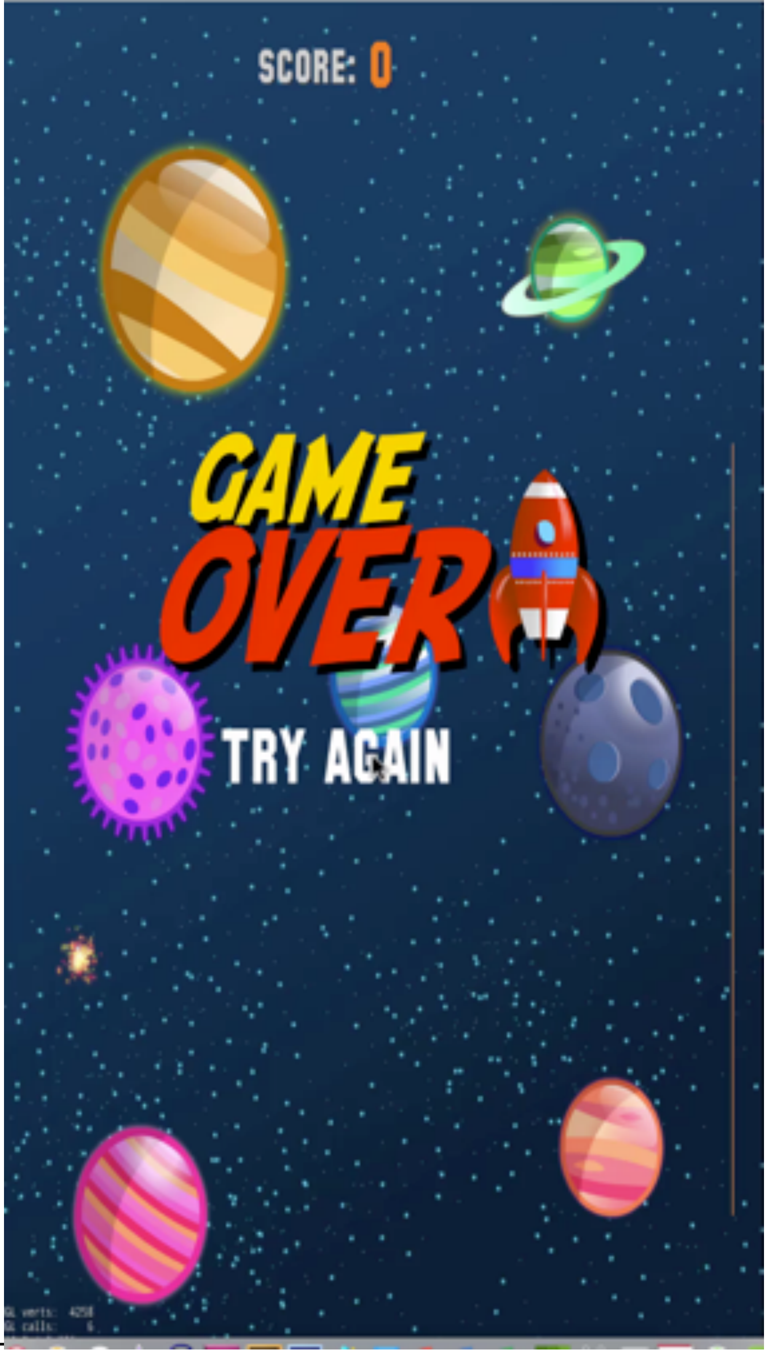
Example: Bouncing Balls (3)

```
        (update contd.)

        # Do time based movement
        self.position += self.speed * time_passed
        # Add gravity
        self.speed.y += time_passed * GRAVITY

        if bounce:
            self.play_bounce_sound()
        self.age += time_passed

    def play_bounce_sound(self):
        channel = self.bounce_sound.play()
        if channel is not None:
            left, right =
               stereo_pan(self.position.x, SCREEN_SIZE[0])
            channel.set_volume(left, right)

def stereo_pan(x_coord, screen_width):
    right_volume = float(x_coord)/screen_width
    left_volume = 1.0 - right_volume
    return (left_volume, right_volume)
```

Multiple Bouncing Balls



Example: Rocket Through Game (Cocos2d-x)



Question:
Which different *types* of sound effects do we have here?

Playing Sound in Cocos2d-x

- Access audio engine (in Game Layer):

```
#include "SimpleAudioEngine.h"
```

- Play background music (when initializing/resetting game layer):

```
SimpleAudioEngine::getInstance()
     ->playBackgroundMusic("background.mp3", true);
```

  – Please note the usage of the "Singleton" software design pattern

- Render player effect (when initializing/resetting game layer):

```
SimpleAudioEngine::getInstance()->stopAllEffects();
SimpleAudioEngine::getInstance()->playEffect("rocket.wav", true);
```

  – What is the difference between the two sounds played globally?

Beispiel Rocket Through Game: Ereignisabhängiger Sound

- In case player ship is destroyed (method killPlayer()):

```
SimpleAudioEngine::getInstance()->stopBackgroundMusic();
SimpleAudioEngine::getInstance()->stopAllEffects();
SimpleAudioEngine::getInstance()->playEffect("shipBoom.wav");
```

- Analogously, in running update(), at collision with star:

```
SimpleAudioEngine::getInstance()->playEffect("pickup.wav");
reset(star);
```

Dynamic Adaptation of Sound Effects

- Dependent of actual event:
  - Choosing between alternative sounds
  - Adaptation of sound properties
    - » Volume
    - » Panorama/Balance
- Audio clips:
  - Often property change during playback not supported
  - Adaptation performed at creation time or at playback start time