Videogame engine architecture

Videogames Technology

Objectives

- Introduce the main videogame subsystems
- Deep understanding of the main loop
- Describe different main loop implementation methods

Bibliography

1. *Desarrollo de Videojuegos, Arquitectura del Motor de Videojuegos*. Capitulo 1, sección 2. UCLM.

Table of Contents

Videogame engine architecture

Overview

Videogame engines aims to be independent of the game genre

- Increased design complexity

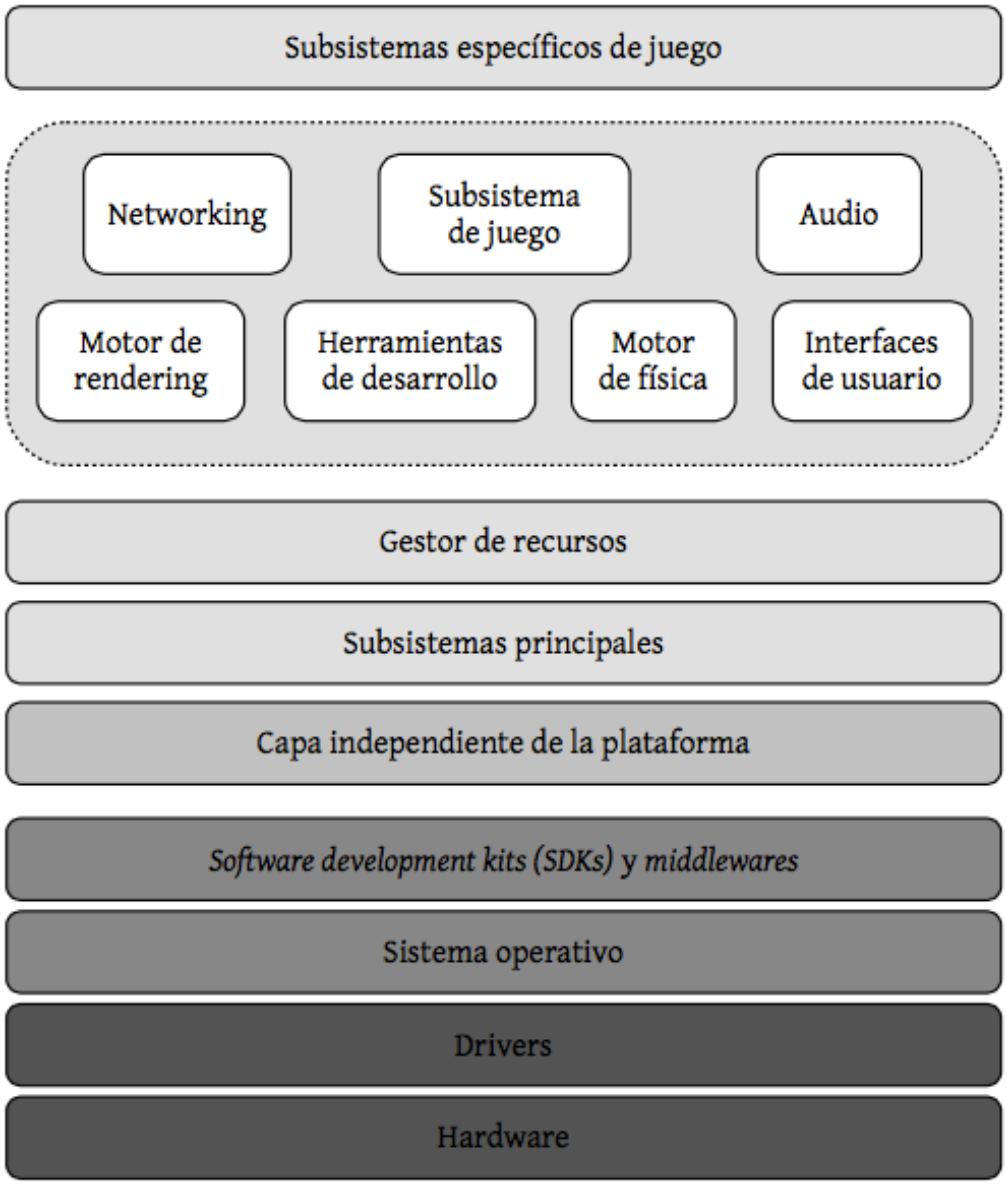
Videogame engines are complex systems $\Rightarrow$ Layered structure

- Layered architectures are common in complex systems
- Handle complexity
- Upper layers use services from the bottom layers
- Lower layers never access upper layers
- Adding layers is simple (well, more or less)
- One layer can be modified independently of the others

Other examples of layered structures: TCP/IP, OSI, operating systems

Videogame engine architecture

Conceptual overview of a videogame engine



Videogame engine architecture

Videogame engine layers (I)

1. **Hardware:** General purpose (PCs) or specific (consoles)
    - The boundaries tend to vanish ...
2. **Drivers:** Interface between processes and hardware
3. **Operating system:** Manages access to hardware
4. **SDK and middlware:** General features not integrated in the OS
    - OpenGL, Direct3D, authentication, etc
5. **Platform independent layer:** Isolates upper layer from the platform
    - Encourages multiplatform games
6. **Main subsystems:** Some basic libraries not dependent on the videogame
    - Mathematical library
    - Datastructures and algorithms
    - Memory management
    - Debugging and logging

Videogame engine architecture

Videogame engine layers (II)

7. **Resource manager:** Unified interface to access videogame resources
    - Many game engines do not implement this
8. **Main subsystems:** General purpose (PCs) or specific (consoles)
    - The boundaries tend to vanish ...
9. **Resource manager:** Manages access to hardware
10. **SDK and middlware:** General purpose libraries
    - OpenGL, Direct3D, etc
11. **Platform independent layer:** Isolates upper layer from the platform
    - Encourages multiplatform games

Videogame engine architecture

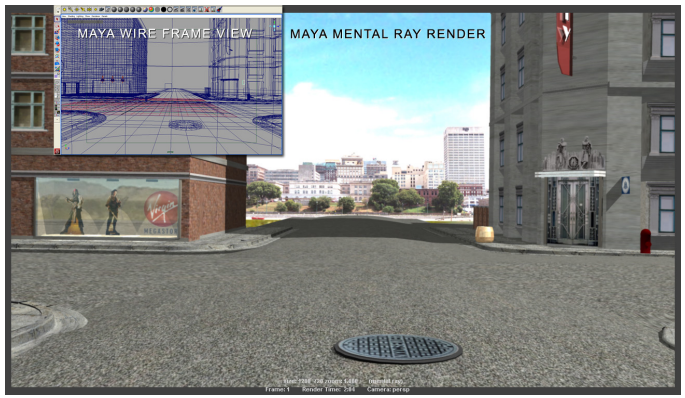
Videogame engine layers (III)

12. **Game specific subsystems:**
    - Physics engine
        - Solid state physics (Video 1) (Video 2) (Video fails)
          Havoc, PhysX, Bullet, ODE
        - Particle physics (Video 1) (Video 2)
    - Collisions engine (usually integrated in physics)
        1. Collision detection
        2. Collision determination
        3. Collision handling
    - User interface (UI)
    - Networking
    - Audio
    - Rendering engine

Videogame models

Render loop (I)

- Part of the rendering engine subsystem
- The render loop handles visualization and rendering
- Objectives in 2D games
  - Minimize pixels to draw: Draw only those pixels that have changed
  - Maximize fps



Render example

- Objectives in 3D games
  - Camera uses to change everytime: The same technique cannot be used
  - Minimize the number of primites to draw in each iteration of the render loop

Videogame models

Render loop (II)

Render loop

```
while (true) {
  // Update camera, usually according to a
  // predefined path
  updateCamera();

  // Update position, orientation and rest
  // of the state of the entities in the game
  updateSceneEntitites();

  // Render a frame in a buffer
  renderScene();

  // Interchage the buffer to visualize the image
  swapBuffers();
}
```

Info: http://wiki.wxwidgets.org/Making_a_render_loop

Videogame models

Game loop (I)

The main element in a videogame is the game loop

- It is the main control structure in the game
- It controls its execution
- It handlers the transitions among states
- The game loop independizes the game execution from the hardware

Classical programs only reacts with user actions

- Videogames are always performing an action
- Game loop implements this easely
- The game engine contains the game loop

Videogame models

Game loop (II)

- There are many subsystems in a videogame
  - Rendering engine
  - Physics and collision detection
  - AI subsystem
  - Game subsystem
- Most of these subsystems require periodic updates
- The most critical one is the animation system
  - Frequency: 30 or 60 Hz
  - Syncronized with the rendering subsystem
  - Objective: Provide a good fps rate to generate a realistic experience
- Not all the components are so strict, for instance, AI

Videogame models

Game loop (III)

- There are several ways to implement the game loop
- The easiest one is to have several loops within the game loop
  - Render loop
  - AI loop
  - Multimedia loop
  - Iteration loop

Basic game loop

```
boolean running = true;

while (running) {
  updateGame();
  displayGame();
}
```

Game loop

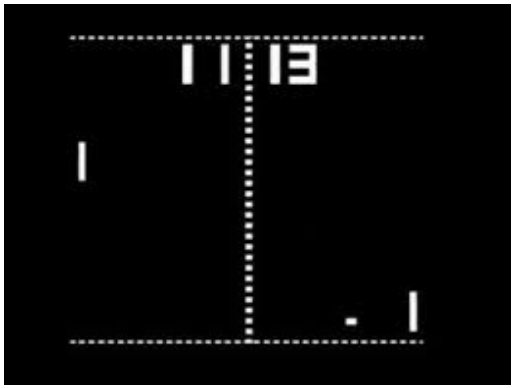
```
while(running) {
  checkUserInput();
  runAI();
  moveEnemies();
  resolveCollisions();
  drawGraphics(); //Render loop
  playSound();
}
```

Videogame models

Game loop (IV)

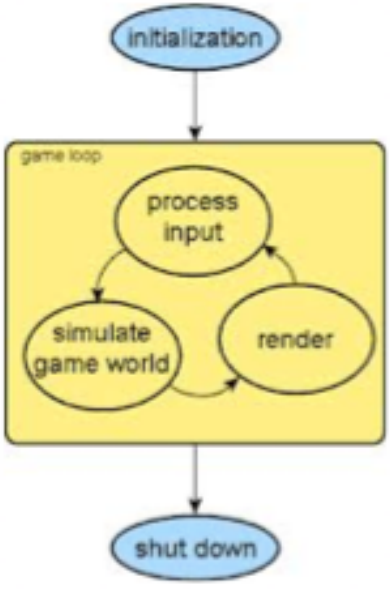
```
int main (int argc, char* argv[]) {
  init_game(); // Game initialization

  while (1) {  // Game loop
    capture_events(); // Capture events
    if (exitKeyPressed()) break; // Exit
    move_paddles(); // Update paddles
    move_ball();  // update ball
    collision_detection();
    if (ballReachedBorder(LEFT_PLAYER)) {
      score(RIGHT_PLAYER);
      reset_ball();
    }
    if (ballReachedBorder(RIGHT_PLAYER)) {
      score(LEFT_PLAYER);
      reset_ball();
    }
    render();
  }
}
```

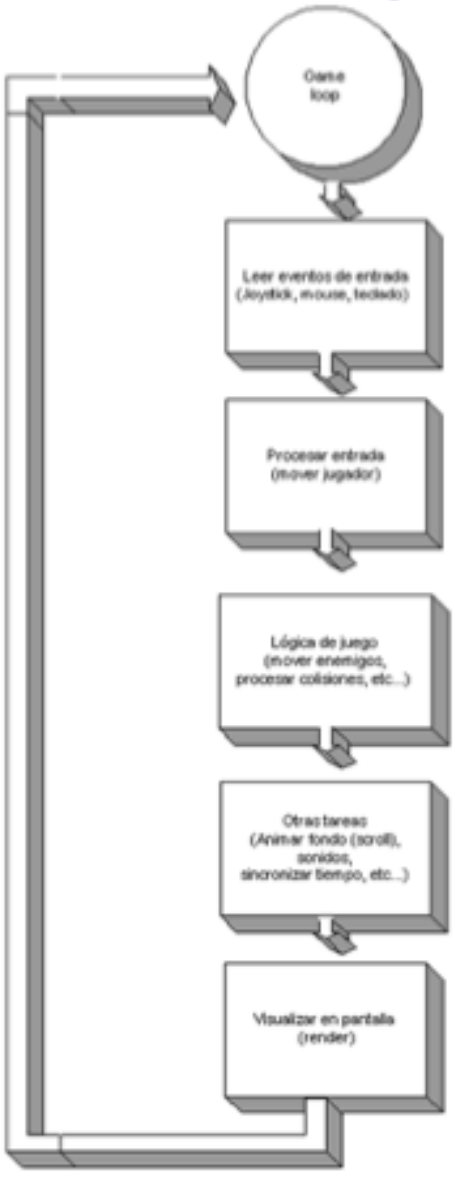
Pong game loop example

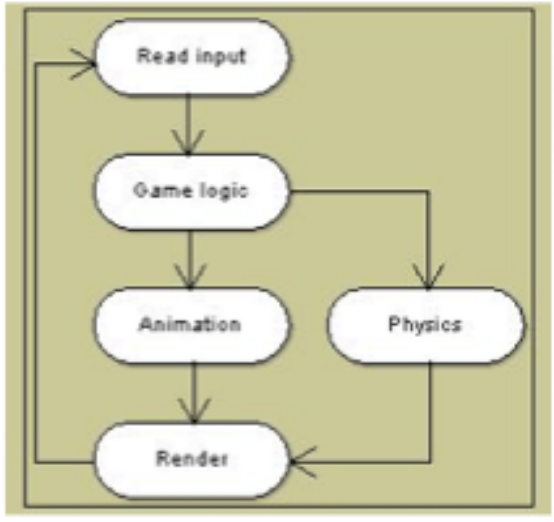


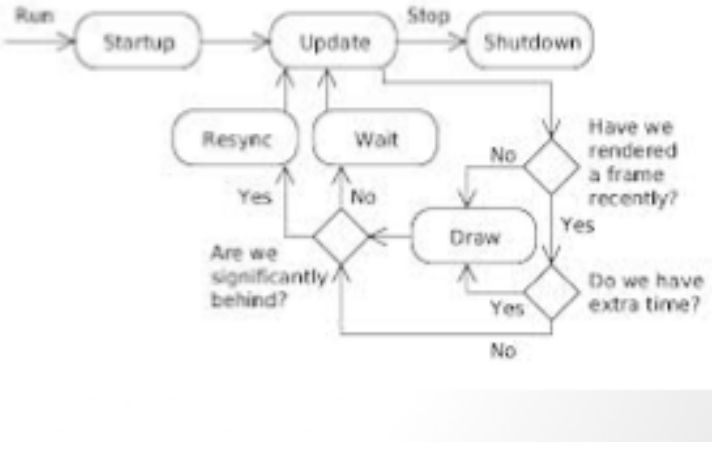
Videogame models

Game loop (V)









Videogame models

Game loop (VI)

The game loop depends on the platform

- DOS games and some consoles are designed to exploit computational resources
- PC games depend on limitations imposed by the OS
- Games use to be multithreaded to exploit multicore machines

Exercise

1. Open the Space Invaders source code available on `https://github.com/leerob/Space_Invaders/blob/master/spaceinvaders.py`
2. Locate the game main loop

Game architectures

Game architectures

Game loop can be implemented in different ways

- Architectures based on callbacks
- Architectures based on events
- Architectures based on state machines

Most of them implement one or more control loops

Game architectures

Callbacks (I)

- **Callbacks**: Code that is executed to handle an event
  - Function or object
  - Callbacks are used to ``fill'' source code
- Related term: **framework**
  - Application partially completed that the developer has to complete

Videogame models

Callbacks (II)

```
void update (unsigned char key, int x, int y) {
  Rearthyear += 0.2;
  Rearthday += 0.2;
  glutPostRedisplay();
}
// More code
int main (int argc, char** argv) {
  glutInit(&argc, argv);

  glutInitDisplayMode(GLUT_RGB | GLUT_DOUBLE);
  glutInitWindowSize(640, 480);
  glutCreateWindow("Session #04 - Solar System");
  // Define callbacks
  glutDisplayFunc(display);
  glutReshapeFunc(resize);
  glutKeyboardFunc(update);

  glutMainLoop();
  return 0;
}
```

Game architectures

Events

- An event represents a change in the game state
- Two types
  - **External**: Generated by the interactions
    Example, The player press a key or moves the joystick
  - **Internal**: Generated by the game logic
    Example, NPC respawn
- Most game engines include an event subsystem
  - Closely related to the *Observer* pattern

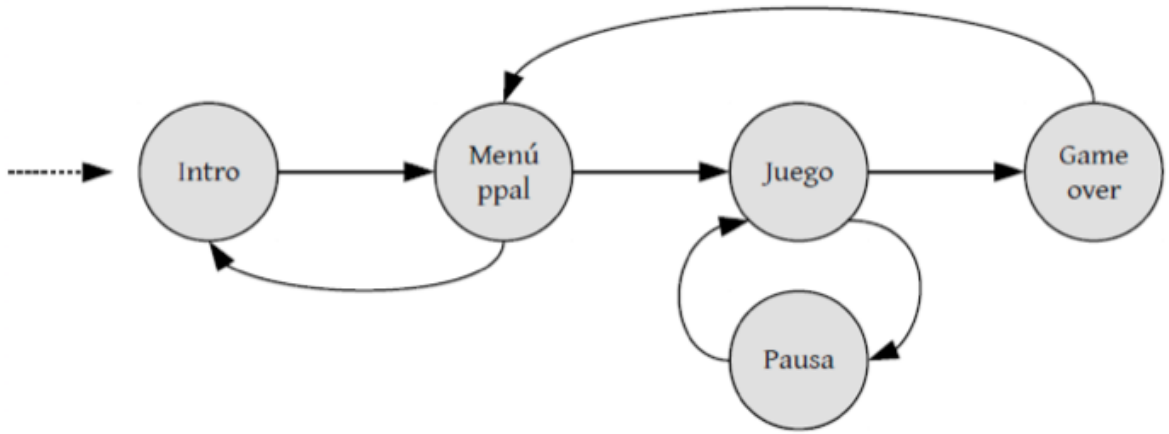
Game architectures

State machine

A game goes through a number of states

- Introduction
- Main menu
- Game
- Game over

State machine: A set of states and transitions



Warning: State machines play a mayor role in game AI