Video Game Technologies

11498: MSc in Computer Science and Engineering
11156: MSc in Game Design and Development

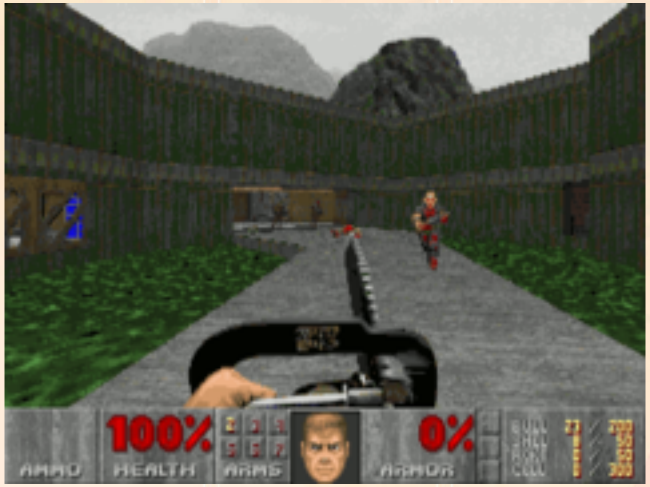
Chap. 2 — Game Engines

Overview

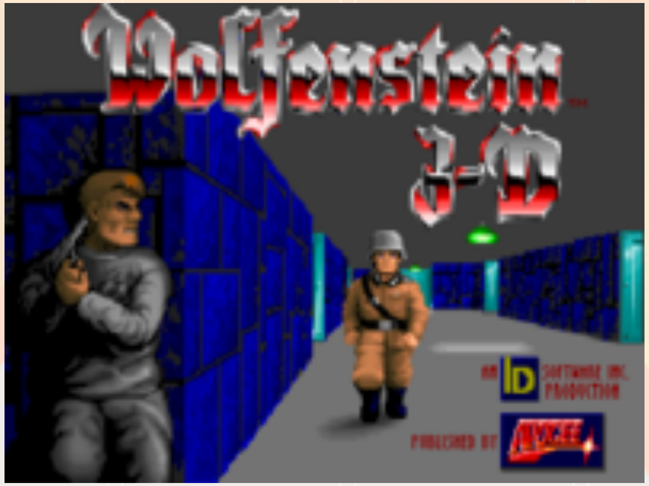
- What is a game engine?
- Game engines:
  - Commercial
  - Open source
- Game engine architecture
  - Physics, AI, Graphics, etc.

What is a game engine?

- A **game engine** is the core software component of a computer or video game or other interactive application with real-time graphics (taken from Wikipedia)
- The term "game engine" was coined in the mid-1990s due to the development of first person shooters such as *Doom, Wolfenstein 3D...*



Episode I: Knee-Deep in the Dead takes place in the facilities of the UAC and the military on Phobos.



The title screen showing the protagonist B.J. Blazkowicz waiting in ambush.

Game engine: main goals

- Provide for underlying technologies
  - Graphics Rendering
  - Physics engine
  - Sound
  - Scripting
  - Animation
  - Artificial Intelligence
  - Networking
  - …
- Simplify development process
- Run on multiple platforms

Top 10 commercial engines

(http://www.develop-online.net) at Friday, 26th June 2009

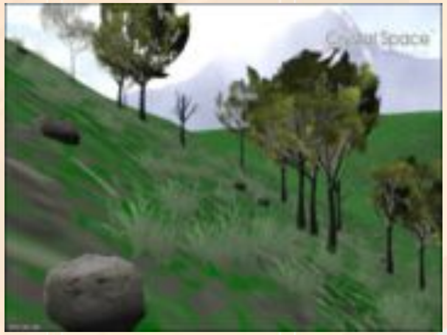
- Unreal Engine 3
- Gamebryo Lightspeed
- CryEngine 3
- Unity 3D
- BlitzTech
- Infernal Engine
- Vision Engine 7.5
- Bigworld Technology Suite
- Vicious Engine 2
- Torque 3D

Unreal Engine

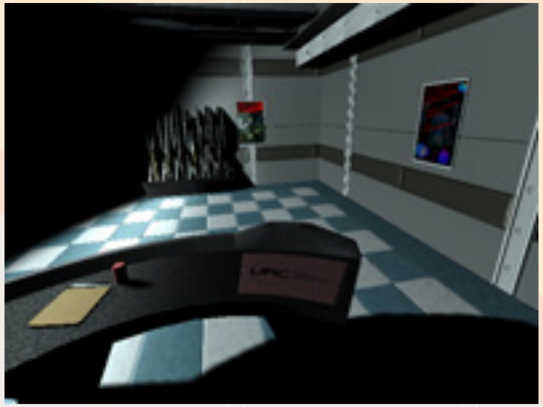
Torque 3D

Open source engines

- OGRE
- Panda3D
- Crystal Space
- Irrlicht



Crystal Space’s folliage generator



Blackout: a Panda3D game using high-end lighting for ambiance.

Irrlicht game

Game middleware

- Components in game engines can be based on **middleware** (Havok, SpeedTree, ...)
- Increasing popularity of MMOGs spawns new middlewares:
  - Gamebryo, HeroEngine, RealmCrafter, MultiverseNetwork, ...
- **Advantages in using a game engine:**
  - Less development time required
  - Less testing and debugging
  - Many features directly available
  - Better focus on the game design
- **Disadvantages in using a game engine:**
  - No control over the implementation of features
  - Adding features not yet in the game engine might be cumbersome
  - Dependent on other licensing scheme for release
  - Other libraries/toolkits linked with the game engine (physics, AI...)

The game loop

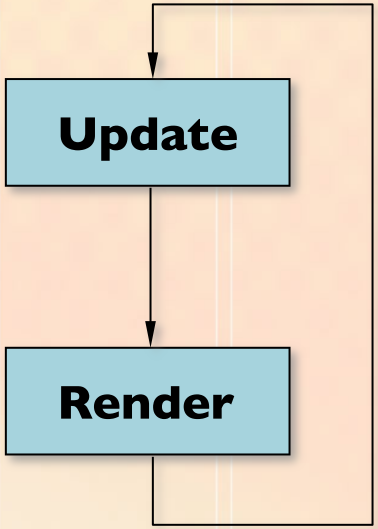
- A game is a real-time interactive application

- Three tasks that run concurrently:
  - Recompute the state of the world
  - The player interacts with the world
  - The resulting state must be presented to the user (graphics, sound, etc.)

- Limitations of real-world technology
  - 1-2 processors with limited memory and speed

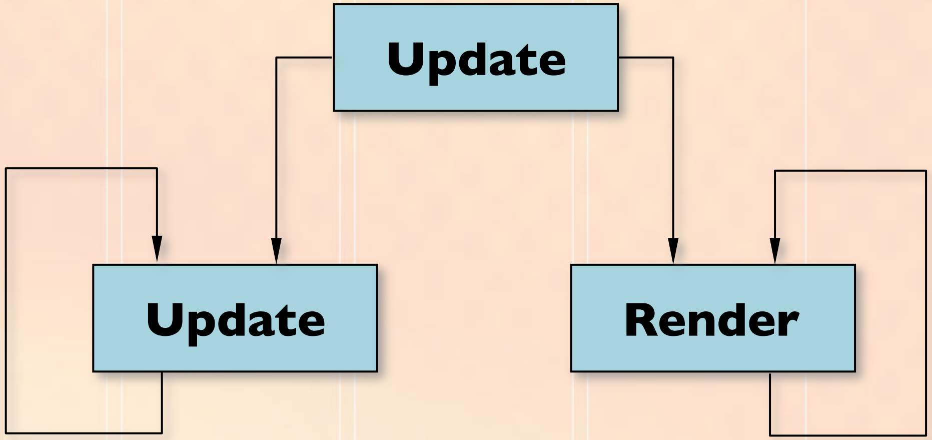
The game loop: *coupled approach*

- 1st try: design update/render process in a single loop (coupled approach).
- **Advantages** of the coupled approach:
  - Both routines are given equal importance
  - Logic and presentation are fully coupled
- **Disadvantages**:
  - Variation in complexity in one of the two routines influences the other one
  - No control over how often a routine is updated

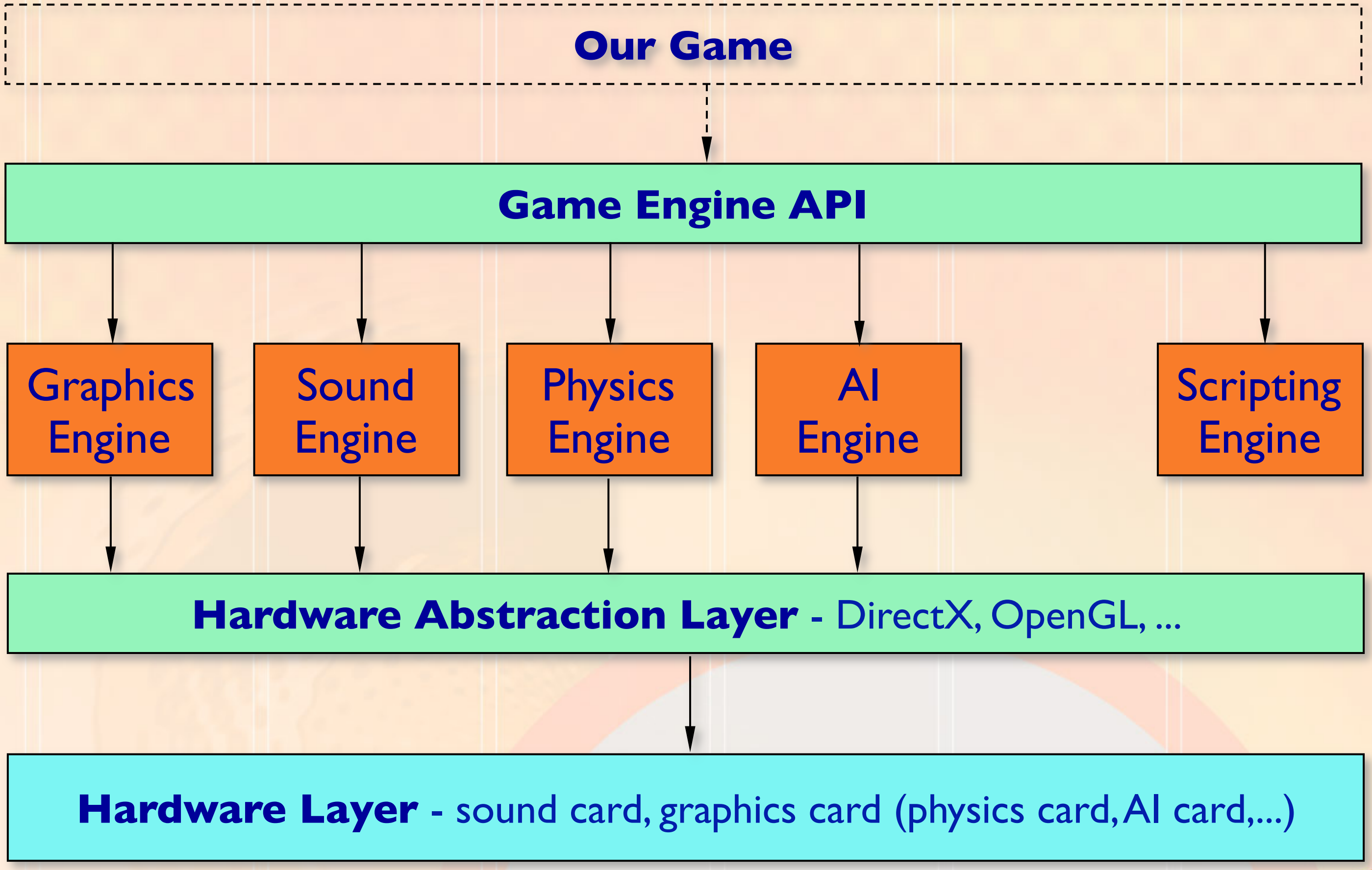


The game loop: *multi-threaded approach*

- 2nd try: design update process using two threads:
- **Advantages** of the multi-threaded approach:
  - Both update and render loops run at their own frame rate
- **Disadvantages**:
  - Not all machines are that good at handling threads (precise timing problems)
  - Synchronization issues (two threads accessing the same data)



Game engine architecture



Our Game

Game Engine API

Graphics Engine

Sound Engine

Physics Engine

AI Engine

Scripting Engine

Hardware Abstraction Layer - DirectX, OpenGL, ...

Hardware Layer - sound card, graphics card (physics card, AI card,...)

Hardware layer

- Physical
  - Graphics card
  - Sound card
  - Physics card
  - Input devices (keyboard, mouse, joysticks, game pads, steering wheels, ...)
- Drivers
  - Low level interface

Hardware abstraction layer

- DirectX
  - HAL (hardware abstraction layer)
  - Components
    - DirectDraw, Direct3D
    - DirectSound, DirectMusic
    - DirectInput, DirectPlay
    - (DirectSetup)
  - Still low level routines
- OpenGL
- Others

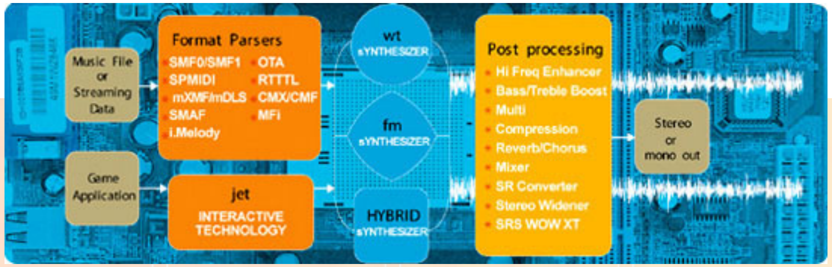
User interface

- To develop a generic high level design for a simple (2D) game.
- Rather simple
- Monitors input devices and buffers any data received
- Displays menus and online help (can nowadays be pretty complex)
- Should be reusable, especially as a part of a game engine

Graphics engine

- Higher level interface, tuned to a particular graphics and game type
  - Sprite-based
  - Isometric
  - Full 3D
- Can deal with higher level modeling concepts
  - Sprites
  - Solids
  - Characters (articulated) ...
  - ***Scene Manager***
    - Each scene is represented by a scene graph
    - Contains everything that appears on the screen
    - There may be different scene managers for terrain (heightmap), exterior and interior scenes, ...
- Handles more complicated display aspects
  - Mini map
  - Multiple views
  - Overlays
  - Special effects ...
- Some of these engines are for sale or available on the web
- Often remade or heavily tuned for each game
  - Too much time and money is spent on this

Sound engine



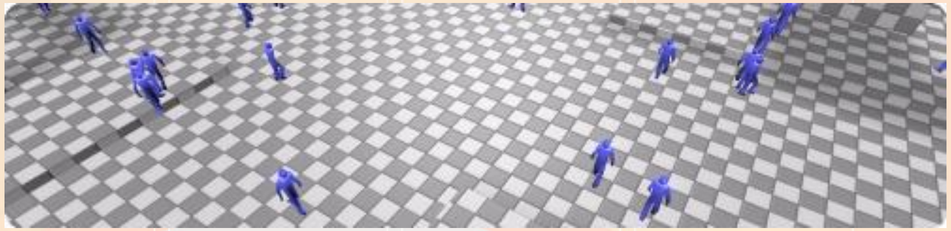
SONiVOX® Embedded Audio Synthesis (EAS™) technology is a multi-platform audio engine for embedded systems and devices

- Function of sound
  - Effects to enhance reality
  - Ambience
  - Clues about what to do
  - Clues about what is about to happen (but be careful)
- Sound formats
  - Wave (high quality, lots of memory, fast)
  - MP3 (high quality, compressed, slower)
  - Midi (lower quality, very low storage, limited, adaptable)
  - CD (Very high quality, fast, limited to background music)
- Simultaneous sounds
  - Mixers (hidden in the HAL)
  - Buffer management
  - Streaming sound
- Special features
  - Positional 3D sound (possibly with Dolby surround)
    - Important for clues
  - Adaptive music (DirectMusic)
- Some sound engines:
  - Wwise
  - FMOD
  - Razer Maelstrom
  - EAS

AI engine

- Behaviour& interaction (dialogue) scripts
  - Especially in adventure games
- Flocking
- Obstacle avoidance
- Attack strategies
  - Hiding
  - Attacking player as a team of enemies
- Decision making
- Path planning
  - Search algorithms
  - Waypoint networks
- Crowd behaviours
  - Panic, riots, ...

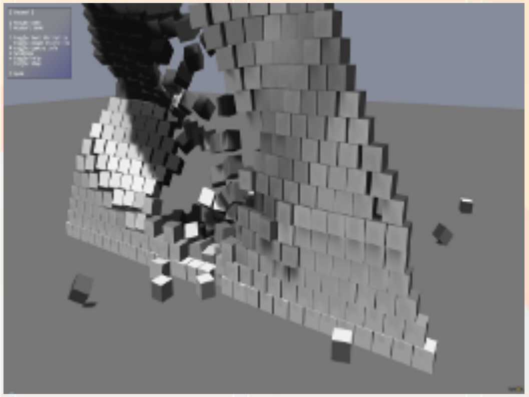
- AI engines that are available:
  - AI-Implant
  - DirectIA
  - SimBionic
  - AISeek (dedicated AI card)



AI.IMPLANT

Physics engine

- Handles the simulation of the world
  - Collisions
  - Terrain changes
  - Waves in the sea
  - Explosions
  - Object destruction
- Limited or non-existent in simple games
- Some commercial/open source engines:
  - ODE (Open Dynamics Engine)
  - Havok
  - Tokamak
  - JigLib
- Physics hardware:
  - Nvidia/Ageia PhysX
- Physics is more and more integrated into the gameplay and game subsystems
  - Physics-based animation
  - Interaction with objects using physics

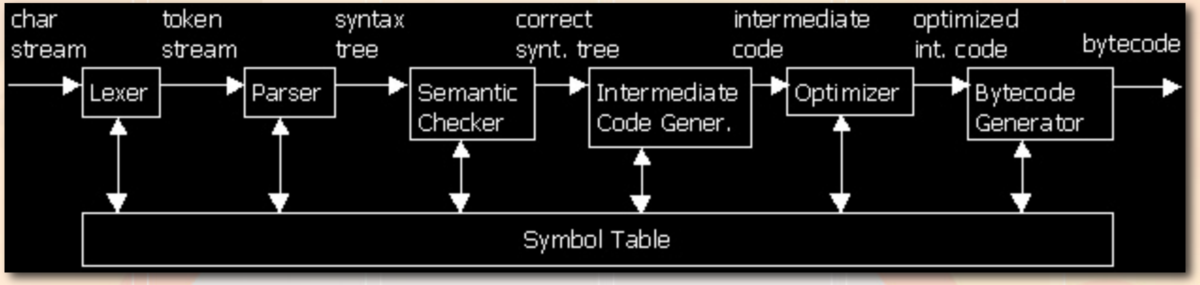


Scripting engine

- **Advantages**:
  - Easy control of many (or all) features in the game engine
  - Scripting language often provides full OO control (like Lua)
  - Promotes data-driven design
- **Disadvantages**:
  - Performance
  - Development support tools
  - Learning curve
- Common scripting languages:
  - Python, Lua, GameMonkey, and AngelScript

http://www.flipcode.com/archives/Implementing_A_Scripting_Engine-Part_1_Overview.shtml

Implementing A Scripting Engine



char stream → Lexer → token stream → Parser → syntax tree → Semantic Checker → correct synt. tree → Intermediate Code Gener. → intermediate code → Optimizer → optimized int. code → Bytecode Generator → bytecode

Symbol Table

Scripting engine (*cont.*)

- What belongs in the engine and what belongs in the script?

engine

Graphics

Rendering

Shadows/lighting

Occlusion culling

Physics

Dynamics

Collision detection

Raycasts

AI

Path-finding

Fuzzy controllers

Planning/A* search

script

Graphics

Tome-of-day

Add/remove lights

Load/moving objects

Physics

Object mass/friction

Collision events

Raycasts events

AI

Path selection

Decision making

Goals/Objectives

Summary:

- What is a game engine?
- Why to build up a game engine?
- Game engines:
  - Commercial
  - Open source
- Game engine components and middleware
- The game loop
- Game Engine Architecture
  - Physics, AI, Graphics, etc.