Principles of Computer Game Design and Implementation

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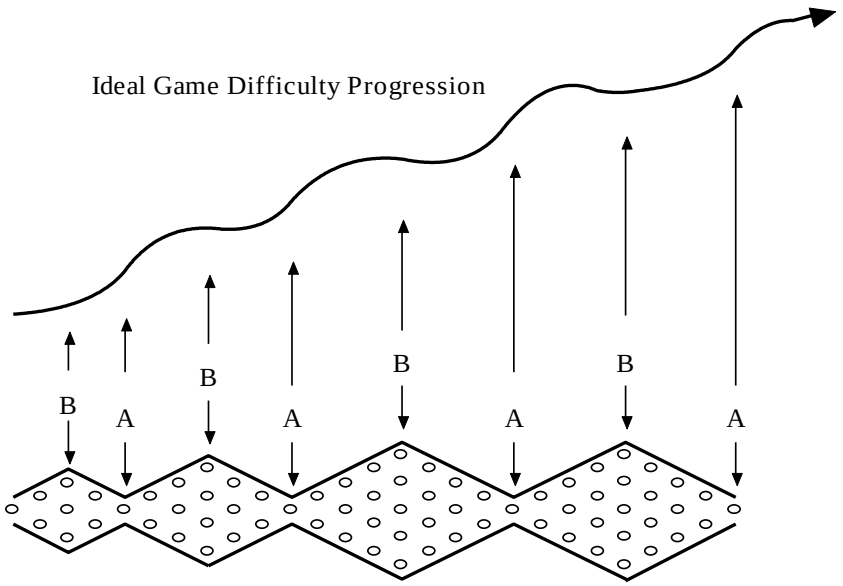
Revision Lecture

Introduction

- Brief history; game genres
- Game structure
  - “A series of interesting choices…”
  - Series of convexities
  - Variable difficulty increase

Mock Exam Questions

- In your opinion, why do game developers often design the game so periods of increased difficulty follow more relaxed periods?



Game Architecture

- Advantages of modular architectures
- Game structure
  - Game code
  - Game engine
  - Tools
- Game loop
- Implementation languages

Mock Exam Questions

- What is the difference between game engine and game code?
- Describe the functionality of the main game loop. Illustrate your answer with a drawing.

Game Engine

- jMonkeyEngine basics
- Image synthesis
  - Model
  - View
  - Renderer
- Scene graph
  - Geometries
  - Nodes

Mock Exam Questions

- Describe the role of a renderer in the image synthesis process.
- What purpose do internal nodes have in a scene graph?
- Explain how transformations are applied to scene graph nodes.

Mathematical Concepts

- 2D and 3D vectors
- Translation
- Unit vectors
- Uniform motion
- Vector arithmetic
  - $\mathbf{V}+\mathbf{W}$
  - $\mathbf{V}-\mathbf{W}$
  - $k\mathbf{V}$

Mock Exam Questions

- Let **V** = (1,2,3) and **W** = (4,5,6). Find the value of
  - **V**+**W**
  - **V**-**W**
  - 3**V**

Transformations

- Rotation
- Applied trigonometry
- Transformation matrix
- Matrix multiplication
- Vectors as 1x3 matrices

Mock Exam Questions

- Let **V** = (1,2,3) and **W** = (4,5,6). Find the angle between **V** and **W**.
- Let

$$\mathbf{M} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \text{ and } \mathbf{M}' = \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix}$$

  - Compute $\mathbf{M}\mathbf{M}'$
  - Compute $\mathbf{M}' \begin{bmatrix} 1 \\ 2 \end{bmatrix}$

Dot & Cross Products

- Local coordinate systems
- Dot product
  - Vector length
  - Measuring angles
    - Classifying angles
  - Projection
- Cross product
  - Normals

Mock Exam Questions

- Let **V** = (1,2,3) and **W** = (4,5,6). Find the value of
  - **V**•**W**
  - **V**×**W**
  - |**V**|
  - Find a vector orthogonal to both **V** and **W**

Collision Detection

- Overlap test V intersection test
- Consequences of poor collision detection
- Bounding volumes
  - AABB
  - OBB
  - Bounding spheres
  - Separating bounding volume
  - Bounding volume hierarchies

Mock Exam Questions

- What game artefacts are a consequence of poor collision detection?
- Simple bounding volume shapes include spheres. Name one advantage of sphere over other bounding volume shapes.
- Outline a method that, given coordinates (x_1,y_1), (x_2,y_2) and radiuses r_1, r_2 of two bounding spheres determines if they overlap.

Spatial Data Structures

- Grids
- Spatial hash
- Quad- and octrees
- k-d trees
- Binary space partitioning trees
  - Solid leaf BSP trees

Collision Response

- Animation V physics-based response
- Kinematics V dynamics
- Particle motion
- Euler steps
- Targeting problem
- Ball-plain collision
- Ball-ball collision

Mock Exam Questions

- Are there any advantages of collision response based on animation compared to collision response based on accurate physical modelling of collision?
- A ball moving uniformly with a constant speed collides with a stationary ball of the same mass. Assuming that collision is elastic, what will be the outcome of the collision?

Physics Engine

- Advantages and disadvantages (V home-grown solution)
- Integration with the game engine

Mock Exam Questions

- Name two advantages of using a home-grown physics implementation compared with using a third-party physics engine.

Game AI

- What is game AI
  - V traditional AI discipline
- Requirement to game AI
- Intelligent entities
  - Virtual player
  - Agents
    - Sense-think-act cycle

Mock Exam Questions

- Discuss the differences between game AI and the traditional AI discipline.
- What are the requirements on computer game AI?
- Explain the difference between a virtual player and an intelligent agent.
- What is meant by 100% optimisation in computer game AI?

Game Tree

- Board games
  - Minimax
  - Chance games. Expectiminimax

Mock Exam Questions

- Given a game tree, find out the minimax value of the root.
- Given a chance game tree, find the expectiminimax value of the root.

Decision Making (1)

- Decision tree
  - Advantages over hard-coding choices
  - Learning decision trees
- Rule based systems in games
- Finite state machines
  - Basic defs
  - Implementation approaches
  - HFSMs

Mock Exam Question

- Given the following table representing decisions taken by human players, and considering attributes in the order ***Ammo, Cover, Health***, learn a decision tree.

Health	Cover	Ammo	Decision
Healthy	In Cover	With Ammo	Attack
Hurt	In Cover	With Ammo	Attack
Healthy	In Cover	Empty	Defend
Hurt	In Cover	Empty	Defend
Hurt	Exposed	With Ammo	Defend

Mock Exam Questions

- Assume you are modelling the behaviour of a cleaner robot, that constantly goes through three states: ***Search for trash***, ***head for trash***, ***head for container***.
  - What decision making model is best suitable to represent this behaviour.
  - Model the robot behaviour clearly indicating states and transitions.
  - Extend the model with the ability for the robot to interrupt and recharge making sure that the robot comes back into the state in which it was before power went low.

Decision Making (2)

- Behaviour trees
  - Architecture
    - Actions, conditions, decorators
  - Emerging behaviour
- Planning
  - GOB & GOAP
  - STRIPS planning
  - Hierarchical plans

Mock Exam Question

- Represent the following agent behaviour in a behaviour tree.
  - Go to the door
  - If the door is open, go into the room
  - If the door is locked
    - If you have the key, unlock the door, open it and enter the room
    - Else break through the door and enter the room

  Indicate clearly tests, actions and composites.

Mock Exam Questions

- Consider an agent with
  - Two goals Eat (5) and Sleep (3), where the number represent the insistence of the goal and
  - Three actions:
    - Eat snack: Eat-3, Sleep+0.25
    - Cook dinner: Eat-5, Sleep+3
    - Take a nap: Eat+1, Sleep-2
  - Which of the actions will be chosen by the overall utility reduction method?

Mock Exam Questions

- Given a planning problem find a solution
  - E.g. monkey and banana problem

Character Movement

- Steering behaviours
- Pathfinding
  - Tile-based games
  - 3D
    - Waypoints
    - Navigation meshes
    - Hierarchical pathfinding

Mock Exam Questions

- Discuss the advantages of considering how a character moves on two levels: steering and pathfinding
- Compare waypoint pathfinding with navigational meshes pathfinding. What are advantages and disadvantages of both?

Other Topics

- Animation
  - Keyframe animation, skeletal animation, inverse kinematics
- Procedural content generation

Mock Exam Questions

- What are difficulties in fully automated level generation in computer games?
- What is the purpose of inverse kinematics?