Lecture 10

Game Architecture
2110-Level Apps are Event Driven

Generates event e and then calls method(e) on listener

Registers itself as a listener

JFrame

Application

Listener

Listener

@105dc

method(Event)
Limitations of the Event Model

- Program only reacts to user input
  - Nothing changes if user does nothing
  - Desired behavior for productivity apps

- Games continue without input
  - Character animation
  - Clock timers
  - Enemy AI
  - Physics Simulations
The Game Loop

- Update
- Draw
The Game Loop

- **Update**
  - Cull non-visible objects
  - Transform visible objects
- **Draw**
  - Draw to backing buffer
  - Display backing buffer
The Game Loop

Update
- Receive player input
- Process player actions
- Process NPC actions
- Interactions (e.g. physics)

Draw
- Cull non-visible objects
- Transform visible objects
- Draw to backing buffer
- Display backing buffer
The Game Loop

60 times/s = 16.7 ms

**Update**
- Receive player input
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**Draw**
- Cull non-visible objects
- Transform visible objects
- Draw to backing buffer
- Display backing buffer
Few Words on Drawing

- Drawing needs to be **fast**!
  - Do as little computation as possible
  - But draw as few objects as possible

- Is this a contradiction?
  - Need to compute what to draw
  - So drawing *less* has extra overhead

- **Rule**: do **not** modify game state in draw
  - Any extra computation is local-only
The Game Loop

Receive player input
Process player actions
Process NPC actions
Interactions (e.g. physics)
Player Input

- Traditional input is event-driven
  - Events capture state of controller
  - OS/VM generates events for you
  - Listeners react to events

- Game loop uses **polling** for input
  - Ask for controller state at start of loop
  - **Example**: What is joystick position?
  - If no change, do no actions that loop
Problem with Polling

- Only one event per update loop
  - Multiple events are lost
  - Example: Fast typing

- Captures state at beginning
  - Short events are lost
  - Example: Fast clicks

- Event-driven does not have these problems
  - Captures all events as they happen
Combining Input Approaches

- **LibGDX input is extremely flexible**
  - Every input type supports events OR polling

- **Polling**: *Input* interface
  - Access it through the static class GDX.Input
  - Allows you to read the input state right now

- **Events**: *InputProcessor* interface
  - Register it with the appropriate input device
  - Works exactly like Swing listeners
Problem: Timing

public class MyProcessor implements InputProcessor {

    public void keyTyped(char c) {
        // Do something with input
    }

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Problem: Timing

```
public class MyProcessor implements InputProcessor {
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}
```

No control over when it is invoked

Game Architecture
Classic Producer-Consumer Problem

**Consumer**

- Update
- Draw

**Producer**

- Input Handler

Game Loop
Classic Producer-Consumer Problem

Consumer

Producer

Game Loop

Update

Draw

Buffer

Input Handler
Classic Producer-Consumer Problem

Game Loop

Consumer

Update

Draw

Producer

Buffer

Input Handler

Answer
Classic Producer-Consumer Problem

Consumer

- Update
- Draw

Producer

- Input Handler
- Buffer

Game Loop

Check → Polling!

Answer
Classic Producer-Consumer Problem

Consumer

- Update
- Draw

Producer

- Input Handler
- Buffer

Game Loop

Check

Polling!

Answer

Overwriting?
Buffering Input

- If overwriting an issue, need an event queue
  - Input processor writes at end of the queue
  - Game loop reads from the front of queue

![Event Flow Diagram]

- Generally requires multiple threads
  - Event handler is (usually) OS/VM provided thread
  - Game loop itself is an additional thread
Event Handlers: Really Necessary?

• Most of the time: **No**
  • Frame rate is short: 16.7 ms
  • Most events are > 16.7 ms
  • Event loss not catastrophic

• Buffering is sometimes undesirable
  • Remembers every action ever done
  • But may take a longer time to process
  • If takes too long, just want to abort
Picking the Right Input

Polling
- When game loop is explicit
  - Actively animating screen
  - Must time input correctly
- **Example**: playing the game

Event Driven
- When game loop is implicit
  - Art assets are largely static
  - Nothing to do if no input
- **Example**: a menu screen
The Game Loop

- **Update**
  - Receive player input
  - **Process player actions**
  - Process NPC actions
  - Interactions (e.g. physics)

- **Draw**
Player Actions

- Actions alter the game state
  - Can alter player state: movement
  - Can alter opponent state: damage

- Player actions correspond to user input
  - Choice is determined by input controller
  - Else action is performed by computer

- These are your game verbs!
Abstract Actions from Input

- **Actions**: functions that modify game state
  - move(dx,dy) modifies x, y by dx, dy
  - attack(o) attacks opponent o

- Input controller maps input to actions
  - Read input state from controller
  - Pick an action and call that function

- Input handler should never alter state directly!
Abstract Actions from Input

- **Actions**: functions that modify game state
  - `move(dx,dy)` modifies x, y by dx, dy
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- Input handler should never alter state directly!

*Design versus Implementation*
The Game Loop

- **Update**
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  - Process player actions
  - Process NPC actions
  - Interactions (e.g. physics)

- **Draw**
NPC: Non-Player Character

- NPC is an intelligent computer-controlled entity
  - Unlike a physics object, it can act, not just interact
  - Sometimes called an *agent*
- NPCs have their own actions/verbs
  - But no input controller to choose
- Work on **sense-think-act** cycle
  - **Sense**: perceive the world around it
  - **Think**: choose an action to perform
  - **Act**: update the game state
Act versus Sense-Think

- Act should be *very* fast!
  - Function to update state
  - **Example:** apply velocity
  - Exactly like the player

- Sense-think unique to NPC
  - The *hard* computation
  - Focus of AI lectures

- **Multiplayer:** Replace sense-think with human decision

Alert!
Problem with Sensing

- Sensing may be slow!
  - Consider *all* objects

- Example: morale
  - *n* knights, *n* skeletons
  - Knights fear skeletons
  - Proportional to # seen

- Count skeletons in view
  - $O(n)$ to count skeletons
  - $O(n^2)$ for all units

```
Time per tick
```

![Game Architectures](image)
Processing NPCs

• Naïve solution: **sequentially**

• **Problem**: NPCs react too fast!
  • Each reads the actions of previous
  • Even before drawn on screen!
Processing NPCs

- Naïve solution: **sequentially**

- **Problem**: NPCs react too fast!
  - Each reads the actions of previous
  - Even before drawn on screen!

- **Idea**: only react to what can see
  - *Choose* actions, but don’t perform
  - Once all chosen, then perform
  - Another reason to abstract actions
Processing Actions in Lab 3

- Decides whether to shoot
- Stores intent in the object
- But **DOES NOT** shoot

- Waits until objects commit
- Checks intent in Ship object
- Performs action for intent

Game Architecture
Focus of Game Lab 2
- Crucial if top view
- Major area of research
- Potentially very slow
  - $n$ NPCs, $g$ grid squares
  - Dijkstra: $O(g^2)$
  - For each NPC: $O(ng^2)$

Moving obstacles?
Problem: Pathfinding

- Focus of Game Lab 2
  - Crucial if top view
  - Major area of research
- Potentially very slow
  - $n$ NPCs, grid
  - Dijkstra's: $O(g^2)$
  - For each NPC: $O(ng^2)$
- Moving obstacles?

Often more than 16.7ms
Asynchronous Pathfinding

Looks like input buffering!
Asynchronous Pathfinding

- NPCs do not get answer right away
  - Check every loop until answered
  - Remember request; do not ask again

- What to do until then?
  - Act, but don’t think!
  - If nothing, **fake** something
  - “Stomping Feet” in RTSs
The Game Loop

- **Update**
  - Receive player input
  - Process player actions
  - Process NPC actions
  - *Interactions (e.g. physics)*

- **Draw**
Purpose of a Physics Engine

- Moving objects about the screen
  - **Kinematics**: Without regard to external forces
  - **Dynamics**: The effect of forces on the screen

- Collisions between objects
  - **Collision detection**: Did a collision occur?
  - **Collision resolution**: What do we do?

- More on this issue later (≈ Spring Break)
Physics Engines: Two Levels

- **White Box**: Engine corrects movement errors
  - Update object state ignoring physics
  - Physics engine nudges object until okay

- **Black Box**: Engine handles everything
  - Do not move objects or update state
  - Give forces, mass, velocities, etc. to engine
  - Engine updates to state that is close enough
Almost everything is in loop
- Except asynchronous actions
- Is enough for simple games

How do we organize this loop?
- Do not want spaghetti code
- Distribute over programmers
Architecture: Organizing Your Code

Game Engine
- Input Devices
- Discrete Simulation Engine

Game Content
- Character Scripts
- Character Data
- UI Elements
- Models and Textures
- Sounds

Player
- GUI
- Rendering Engine
- Audio Engine

Programmer
- Physics Engine
- AI Engine (e.g. Pathfinding)

Designer or Modder

Game Architecture
Architecture: Organizing Your Code

Game Engine
- Input Devices
- Discrete Simulation Engine
- GUI
- Rendering Engine
- Audio Engine

Interface

Implementation

Compiler
Data Management Layer
- Character Scripts
- Character Data
- UI Elements
- Models and Textures
- Sounds

Game Content

Programmer
- Physics Engine
- AI Engine (e.g. Pathfinding)

Designer or Modder
Where Did This Come From?

Next Time!