Game Loop and Time

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Importance of Time

• Games are...
  ...real-time, dynamic, interactive computer simulations

• It’s all about time
Render Loop

- Not all applications need to redraw the whole screen image continuously
  - Windows uses method of “rectangle invalidation”
  - Early games used 2D sprites

- 3D games need to display a rapid succession of still images to produce a continuous experience
  - Accomplished with a “render loop”
Typical Render Loop

1. Update Camera
2. Update Scene Elements
3. Render Scene
4. Swap Buffers
Game Loop

- The game engine needs to service a range of subsystems
- Subsystems may require servicing at different rates
Architecture Styles

• Windows message pumps
  – Check and deal with win messages, then do game
• Callback-driven frameworks
  – Implement callback function called by framework
• Event-based updating
  – React to events, schedule recurring events
Abstract Timelines

• Real-time
  – CPU high-resolution time register
• Game time
  – May coincide w. real-time, can be paused/stepped
• Local timeline (e.g. video/animation playback)
• Global timeline (e.g. the real-time clock)
Measuring Time

• Frame Rate
  – How rapidly the still frame sequence is presented

• Frames Per Second (FPS)
  – Films: 24 FPS,
  – Games: 30/60 FPS (US/Japan), 50 FPS (EU)

• Delta Time
  – Time that elapses between showing two frames
  – At 30 FPS, delta time is 1/30 seconds or 33 ms
Speed

• We wish to render a car driving at 60 km/h .... or 50/3 m/s
• Change in position between drawings should be calculated, let’s assume 30 FPS
  \[ \Delta x = \text{speed} \times \Delta t = \frac{50}{3} \text{ m/s} \times \frac{1}{30} \text{ s} = \frac{5}{9} \text{ m} \]
• So, every time we draw, we put the car 5/9 m further along its trajectory
  works as long as we’re getting 30 FPS...
Measuring $\Delta t$

- **Update based on elapsed time**
  - $\Delta t$ calculated when you finish a frame, made available to the next frame
  - But this time from frame $k$ is used when calculating duration for the simulation at frame $k+1$

- **Frame rate spikes can cause trouble**
  - Use running average for $\Delta t$ instead
Frame Rate Governing

- **Set target frame rate, e.g. 60 FPS**
  - If duration of frame is less than 16.6 ms, then sleep for the remainder
  - If duration is greater, then so be it

- **Useful because**
  - Physics run more reliably at constant rate
  - Avoids tearing when buffers get swapped mid-scan
    - Frame rate can be governed by v-sync of display
  - Consistent playback of recorded play
Measuring Time

• `time()`
  – Seconds since midnight, January 1, 1970
  – Resolution 1 second (not enough!)

• High-resolution timer
  – CPU cycles since start-up or reset
  – Resolution 0.33 ns (for a 3 GHz processor)
High-Resolution Timer

• Hardware register
  – Queried with different instructions based on hardware platform
  – Win32 wraps these in QueryPerformanceCounter() and QueryPerformanceFrequency()

• Size of register limits magnitude
  – 64 bit register wraps after 195 years at 3 GHz
  – 32 bit register wraps after 1.4 seconds at 3 GHz
Time Units and Clock Variables

• When we wish to work with time, we ask:
  1. What time unit?
  2. What data type?

• The answers will depend on:
  1. How much precision?
  2. What magnitude range?
Time Variables

- **64 bit integer**
  - High precision, high magnitude, but expensive
- **32 bit integer**
  - High precision for short durations, e.g. Deltas
- **32 bit float**
  - Store values in seconds
  - Careful about magnitude, it can eat up the decimals
  - Good for short time deltas (may need resetting)
Other Time Units

• Game developers can pick arbitrary time units if they wish

• Sometimes use 1/300 second units
  – Even multiple of NTSC 60 Hz and PAL 50 Hz
  – Fairly good sized unit for game related stuff, e.g. AI and object behavior
Break Points

• If you pause execution of program, e.g. for debugging, the $\Delta t$ when you start again will become super large, causing anomalies.

• Fix this by checking in code whether $\Delta t$ is absurdly high, in which case a default value should be used instead.