



## COMP130: Game Architecture

# 4: Game engine architecture

# Research journal



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# The main loop



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  - ▶ E.g. Unreal implements the main loop for you
  - ▶ E.g. PyGame isn’t a game engine, so you have to implement your own main loop

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It does these **once per frame** (typically 30 or 60 times per second)

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while (running)
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- ▶ Also draw any **heads-up display (HUD)** elements, e.g. score, lives, mini-map, etc.
- ▶ Most modern game engines **clear the screen and redraw everything** on every frame

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- ▶ Hence the term **(vertical) refresh rate**
- ▶ Refresh rate is measured in **cycles per second** i.e. **Hz**
- ▶ Other monitor technologies work differently, but still refresh the screen at regular intervals

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- ▶ If the main loop runs too slowly, we get “lag”
- ▶ If the main loop runs too quickly, we waste resources on drawing things faster than the display can show them

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  - ▶ VR headsets:  $90\text{Hz}$
  - ▶ High-end gaming monitors:  $120\text{Hz}$  or higher

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  - ▶ The game could appear to run in slow or fast motion, completely changing the gameplay
- ▶ This was the situation on older consoles:  
American/Japanese versions of games actually ran a little faster than European versions, due to the NTSC TV standard having a higher refresh rate than PAL!

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- ▶ do this:

```
player.positionX += player.velocityX * deltaTime;
```

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float lastFrameTime = getCurrentTime();

while (running)
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- ▶ If refresh rate  $> 50\text{Hz}$ , update once every few frames

# Fixed time step

```
bool running = true;
float lastUpdateTime = getCurrentTime();
float timePerUpdate = 1.0f / 50.0f;

while (running)
{
    float currentFrameTime = getCurrentTime();

    while (currentFrameTime - lastUpdateTime >= ←
           timePerUpdate)
    {
        update();
        lastUpdateTime += timePerUpdate;
    }

    render();
    waitForVerticalRefresh();
}
```

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- ▶ What if `update` takes longer than `timePerUpdate` to execute?



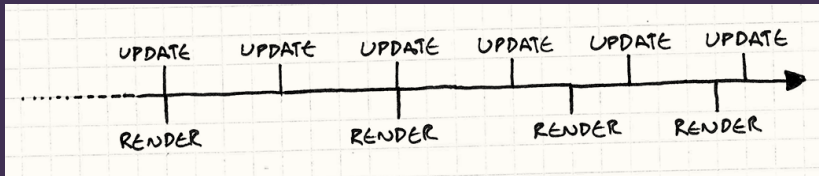
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- ▶ What if `update` takes longer than `timePerUpdate` to execute?
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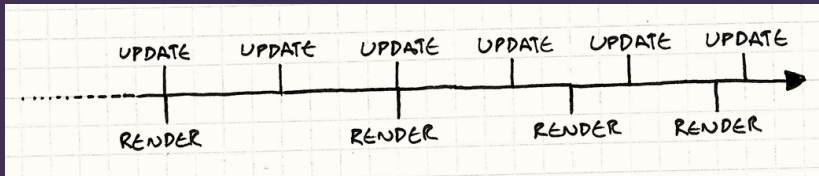
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- ▶ **Solution:** `break` out of the loop after a maximum number of iterations (e.g. 10)

# Interpolation

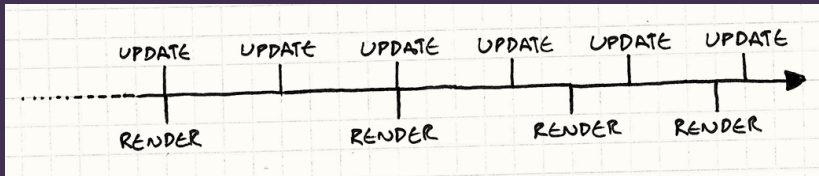


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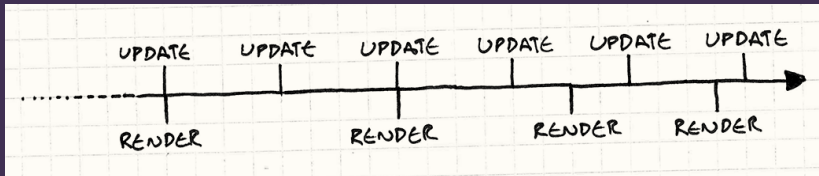
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- ▶ Solution: **interpolate** between the two previous updates
  - ▶ E.g. if the render falls exactly halfway between two updates, render each object exactly halfway between its positions **before** and **after** the most recent update

# Further information on fixed time steps

- ▶ <http://gafferongames.com/game-physics/fix-your-timestep/>
- ▶ <http://gameprogrammingpatterns.com/game-loop.html>

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- ▶ Use fixed time step at low frame rates, variable at high frame rates
- ▶ E.g. again with a target update rate of 50Hz
- ▶ If refresh rate  $< 50\text{Hz}$ , update several times per frame, with a `deltaTime` of  $\frac{1}{50}$
- ▶ If refresh rate  $> 50\text{Hz}$ , update once every frame, with `deltaTime` measured as for variable time step

# Substepping

```
bool running = true;
float lastFrameTime = getCurrentTime();
float timePerUpdate = 1.0f / 50.0f;

while (running)
{
    float currentFrameTime = getCurrentTime();
    float deltaTime = currentFrameTime - lastFrameTime;

    if (deltaTime <= timePerUpdate)
    { // Variable time step
        update(deltaTime);
    }
    else
    { // Fixed time step
        while (deltaTime > 0)
        {
            update(timePerUpdate);
            deltaTime -= timePerUpdate;
        }
    }

    render();
    waitForVerticalRefresh();
    lastFrameTime = currentFrameTime;
}
```

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- ▶ More info: <http://www.aclockworkberry.com/unreal-engine-substepping/>

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- ▶ `Update` function on `MonoBehaviour`s is tied to frame rate
- ▶ `FixedUpdate` function is tied to fixed physics updates

# Game engine components



