Engineering at a Games Company: What do we do?

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The Role of Engineering at a Games Company

- Empower game designers and artists to realize their visions
  - Make tools and systems for designers and artists to use
- Engineering is still heavily involved the creative process
    - Not always good…the creative process is brutal
    - Artists are trained to kill their children

What do you need to know?

- Typical CS Stuff – how to write large programs
  - Software development
  - Memory management, languages
  - Algorithms, Data Structures
  - User Interface (important)
  - Discrete Math
- Other stuff
  - Graphics
    - But not as much as you think
  - 3D Math
  - Simulation & Physics
  - Real-time networking
- Hopefully this class helps with the other stuff!
  - Useful not only for games, but machine vision, robotics, and so on

What tools do we use to make games?

- When Pipeworks started in 1999:
  - Blank hard drives
  - Visual Studio
  - 3ds Max SDK
- Now: Game Engines
  - Unity
  - Unreal
    - A few custom engines survive…
- Art is made with DCC tools
  - Maya, Blender, 3DS Max
  - Photoshop

Eventual Goal

- Eventually, artists and designers will be able to use engines to make games without engineers.
  - This is how it show be: You can make a document w/o engineering!
  - Don't worry….this is decades off
  - Many designers program, so the line is blurry
- The game engine will provide 95+% of the code needed to make the game
  - Again, typical: 95% of the code to display a web page is provided to you
- Our job is to provide what the game engine doesn't

What do we actually Do

- Fix performance problems
- Simplified physics
- Special Graphical Techniques
- UI
- AI
- Procedural Content
- Networking & back-end
- Miscellaneous Yak shaving
- Game code

Fix Performance

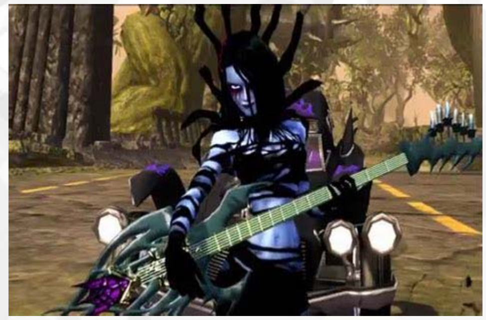
- Dev model: Artists add stuff until there is a problem then figure out why
- The goal is a consistent framerate
  - Stuttering can be very noticeable
  - Amortized speed doesn't count
- Most important thing is to understand the rendering & update pipeline to find bottlenecks
  - Solutions are often content changes, pre-calculation and so forth
  - GPU's hate state change
  - Threading when possible
- Rarely are perf problems fixed with just code changes
  - No more rewriting stuff in assembler
  - Shaders are an exception
- Memory bandwidth problems can dominate

Simplified Physics

- Gameplay is hard to design. Physics is gameplay for "free!"
  - Angry Birds is a demo for Box2D
  - Free until it's not – gameplay has to be predictable and understandable
- Many game engines have very sophisticated physics systems
  - The math is crazy crazy
  - Check out Bullet Physics
- Engineering needed for
  - Optimizations
  - Fractures
  - Predictable behavior
  - Tires/Cloth/Soft bodies
- Many games do better without a complex physics simulation
  - E.g. Roller Coasters

Special Graphical Techniques

- Most shaders can be make by artists
  - DCC tools make graphics easy
  - Writing shaders is now a technical art position
- See Brutal Legend Ink

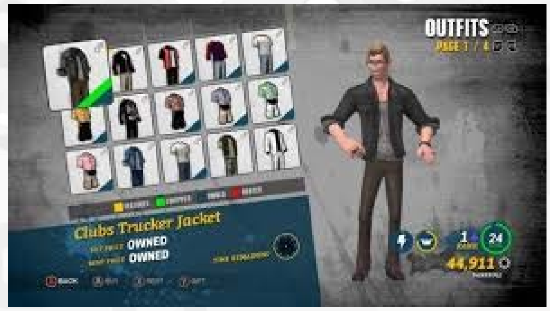


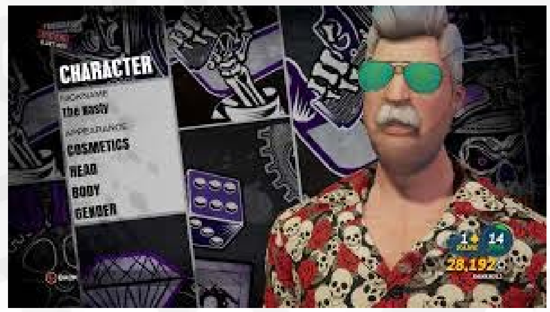
AI

- A Famously vague term
- For games we usually want:
  - Artificial opponents
  - Believable NPC's
  - Optimality not required (or even desirable)
- Usually bespoke and rule-based
  - Harder than you might think
  - Have to know rules in detail
  - Check out Steering Behaviors For Autonomous Characters
- We have been trying to make autonomous vehicles long before it was fashionable. Good luck.

UI

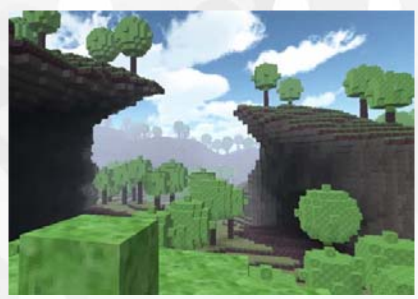
- User interface is important
- Often mixes with 3d in the world
- Rendering is done by the 3d pipeline
  - Using faster than raster methods
- Typical Pipeline:
  - Screen Mock ups made by designers
  - Pretty is added by artists
  - Functionality is from engineering
- Lots of color, and animation and VFX





Procedural Content

- Stuff that artists and designers don't make
- Allows replayability at low-cost
- Avatar systems
  - E.g Character Creation
- User created structures
  - E.g. building in Fortnite
- Foliage
- Crowd and background characters
- Terrain
  - The world in Minecraft or Terraria
- Very game-specific



Networking and Back End

- Managing & debugging a distributed state machine…hard
- Need to hide latency
  - TCP is not good
  - Typically use UDP with some sort of reliability layer – check out Enet
- Ration bandwidth
- Error handling
  - Everything that can go wrong, will…a lot…and users will make it worse
- Interface with databases
  - Predictable performance can be hard

Yak Shaving

- Engineering owns the build/deploy tool chain
  - Jenkins/CI etc.
  - Source control, which is notably difficult for Games
    - Git model does not work as well (but LFS helps)
- Satisfy Console and Platform requirements
  - Far more rigorous than the App Store
- Every software business has this stuff
- We need strong programmers

Game Code

- Camera & Control
- Game rules
- Character animation
- And so on…

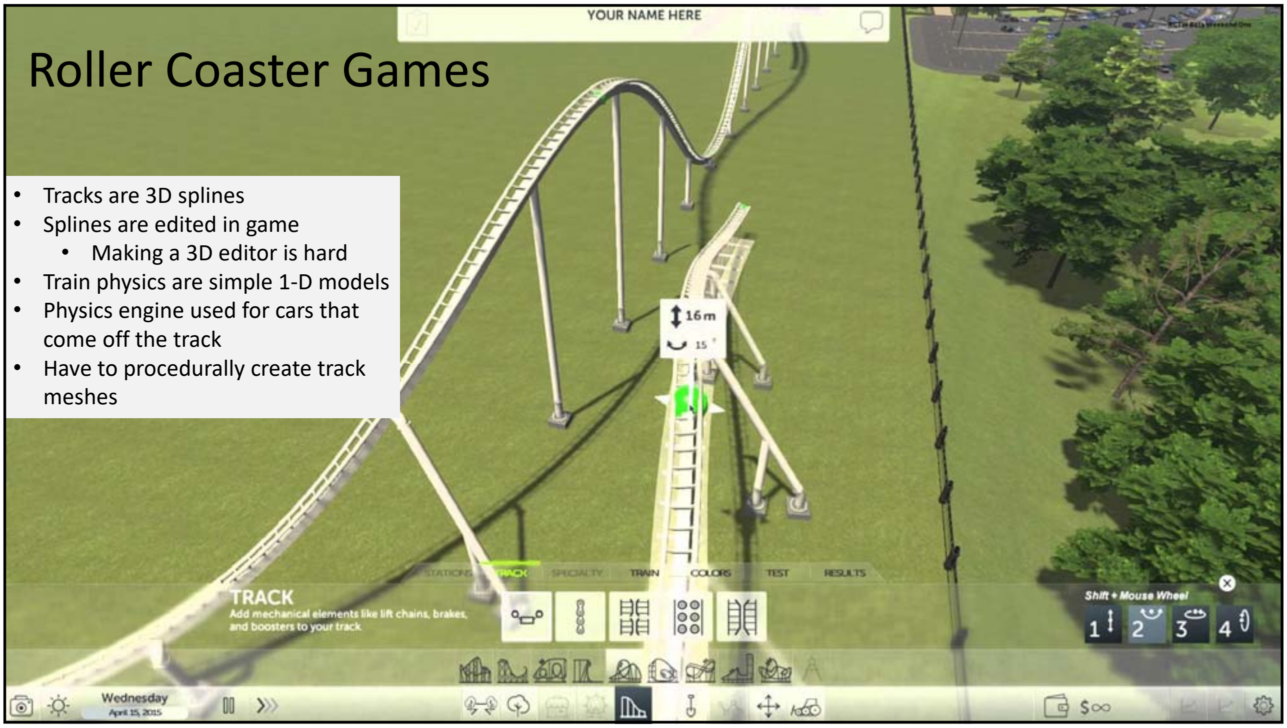
Examples…

Roller Coasters

Fighting Game Camera

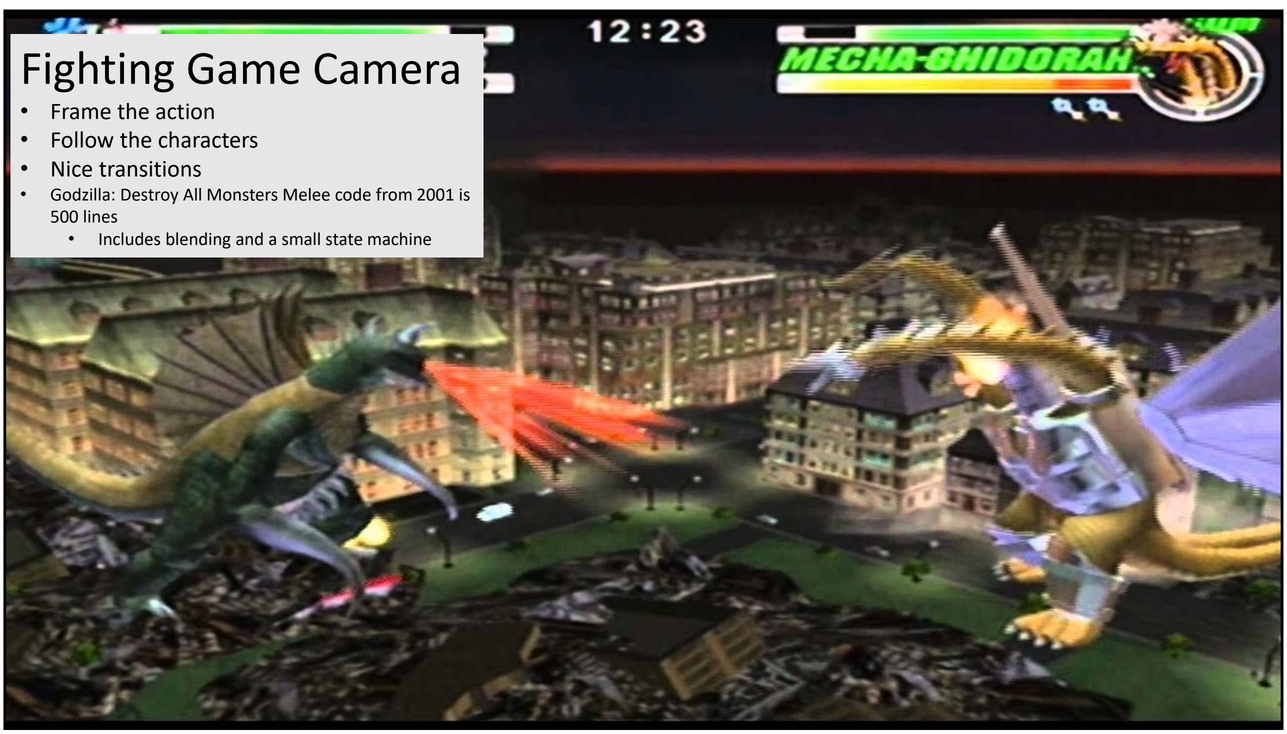
Roller Coaster Games

- Tracks are 3D splines
- Splines are edited in game
    - Making a 3D editor is hard
- Train physics are simple 1-D models
- Physics engine used for cars that come off the track
- Have to procedurally create track meshes



Fighting Game Camera

- Frame the action
- Follow the characters
- Nice transitions
- Godzilla: Destroy All Monsters Melee code from 2001 is 500 lines
    - Includes blending and a small state machine



Underlying Skills

- 3d Math
- Matrices
- Simple physics
- Blending
  - Nature is smooth
- Robustness
- Mesh Manipulation

Robustness: Floating Point is the Devil

- What does this return?
  - Does it even return?

```
float add_forever()
{
    float t = 0;

    while (1)
    {
        float next = t + 1.f / 30;
        if (next == t)
                break;
        t = next;
    }

    return t;
}
```

Answer

1048576.00 = 2^20 = 2^25 / 2^5

- If you update your simulation time this way, time stops after ~12 days
- Most games & graphics software runs on 32-bit float
- A big issues for flight sims and large worlds
- Safety in double is illusory anyway