CPSC 427
Video Game Programming

History and Future of Game Technology
Today

• **Technical highlights in game history**

• **Relations to computer science advances**
  • computer graphics
  • computer vision
  • optics …

• **Course Summary**

• **The future of gaming?**
The Sword of Damocles (1968)

- **By Ivan Sutherland**

- **First augmented reality head-mounted display (HMD)**
  - stereoscopic display
    - *see-through technology!*
  - viewpoint-dependent rendering
    - *required 6 DOF head tracking*
    - *some versions used ultrasound!*

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LIFE (1970)

By John Horton Conway

Rules:
• A pixel grid of active/live and inactive/dead cells
• Any live cell with two or three live neighbours survives
• Any dead cell with three live neighbours becomes a live cell
• All other live cells die in the next generation

The seed (initial condition) determines the evolution
Perlin noise (1983)

Ken Perlin
https://mrl.cs.nyu.edu/~perlin/
NYU

Check out his website!

Two-dimensional slice through 3D Perlin noise at z=0

Landscape by Perlin noise

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Perlin noise

1. Generate random vectors

2. Dot product of rnd. vec. and offset to neighboring corners

3. Interpolate based on distance

4. Repeat at different resolutions and add displacements
The Light Gun (~1985)

http://www.arcadecab.com/News.htm

Classic: NES Zapper
Light Gun parts

- a laser?!

https://makingstudio.blog/2017/09/20/teardown-nintendo-zapper/

```c
float Q_rsqrt( float number )
{
    long i;
    float x2, y;
    const float threehalves = 1.5F;

    x2 = number * 0.5F;
    y = number;
    i = *( long * ) &y;
    i = 0x5f3759df - ( i >> 1 );
    y = *( float * ) &i;
    y = y * ( threehalves - ( x2 * y * y ) );
    // y = y * ( threehalves - ( x2 * y * y ) );

    return y;
}
```

OpenArena (open source version of the original)
Fast inverse sqrt

• \(1/sqrt(x)\)

• For normalizing a vector

\[
\hat{v} = \frac{v}{\|v\|}
\]

• For lighting and reflectance

• How to speed it up?
Fast inverse sqrt

• How to speed it up?
• Only use addition and multiplication (at the time, division was very expensive)

-> 4x speedup compared to division

```c
float Q_rsqrt( float number )
{
    long i;
    float x2, y;
    const float threehalves = 1.5F;

    x2 = number * 0.5F;
    y = number;
    i = * ( long * ) &y;
    i = 0x5f3759df - ( 1 >> 1 );
    // what the f***
    y = y * ( float * ) &i;
    y = y * ( threehalves - ( x2 * y * y ) ); // 1st iteration
    // y = y * ( threehalves - ( x2 * y * y ) ); // 2nd iteration, this can be removed

    return y;
}
```

Used elsewhere before but best known for its use in Quake III Arena!

Magic exploiting floating point representation and \( \log\left( \frac{1}{\sqrt{x}} \right) = -\frac{\log(x)}{2} \)

One step of Newton’s method (root finding)
World of Warcraft - Corrupted Blood Incident

- virtual pandemic
- spread by end boss Hakkar (intended to be local to a single dungeon)
- spread by pets and minions
- lasted one week
- programmer-imposed quarantines
- players' abandoning of densely populated cities
- Model for epidemic research

Pokemon Go (2016)

- **Augmented reality**
  - requires tracking of the real world
  - 6 DOF (3D position and 3D rotation)

Options:
- Use device accelerometers
  - **Advantage: simple**
  - **Disadvantage: drift & no relation to the real world**
- Estimate camera angle relative to real objects

Which one is done in Pokemon Go?
HoloLens - Augmented Reality done right
Virtual Camera

Virtual camera registered in the real world (using marker-based motion capture)

Perspective projection (P)
Spatial mapping and tracking
HoloLens --- Augmented Reality done right

**Input:** gray-scale fisheye cameras (paired with accelerometers)

**Method:** track image features with on-board processor

**Output:** reconstruct the 3D scene and camera pose
Related computer vision concepts

• **Feature detection**

• **Feature tracking and re-identification**

• **Perspective projection**

• **Hand Gesture recognition (as input)**
Virtual and Augmented Reality Issues

Open questions:

• Why are headsets so bulky?

• Why do I get motion sick or perceive discomfort?

• Why is the field of view (FOV) and resolution so low?
3D perception — Binocular

Convergence and accommodation

Near object, Large angle

Far object, Small angle

Binocular parallax

3D scene

Left eye Right eye Parallax

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Head-Mounted Display

Head-Mounted Display (HMD)

Optical setup

Lens

Tracking sensor

Display

[LHD Aufbau: minimalicity.com]
Optik und Virtuelles Display

Linsenvergrößerung

Real display

Stereo-area covered by both display sides

(simplified view without lens)

The perceived display (virtual) is magnified

Lens

Left display

Right display
Stereo-Display

Desired/real object positions

Case I: Object projected on display

Case II: Object is behind the screen

Case III: Object is in front of screen
Issues of VR?

• *What does this imply for us (video game programming)*?
Light field displays (3D without glasses)

**Principle:** a display that emits a different color dependent on the view direction

**Difficulty:**

i) Render an independent image for each view direction (and position).

ii) hardware realization.
Course Summary

1. Intro
2. ECS
3. Rendering
4. Rendering Pipeline
5. Advanced OpenGL
6. Collisions
Course Summary

7. IO & Observer Pattern
8. User Interfaces
9. AI and Trees

10. Path finding
11. Debugging & Simulation
12. Simulation
Course Summary

13. Curves & Animation

14. Game Balancing

15. Skeleton Animation

16. History & Future
The Future?
Streamed games?

- **Cloud gaming** (Stadia, GeForce Now, PlayStation Now, xCloud, Luna)
- **Streaming content at 60+ fps, up to 4k resolution**
- **Can that work?**
  - Multi-player games worked for decades now
  - Internet throughput has increased dramatically
  - Compression has improved too
  - Yes!
- **Minimal delay remains**
  - Predictive input?
AI

• AI characters
  “I do see a future where, within 10 years, whether it’s through mixed-reality headsets or looking at AR through our phones, we’ll have this concept of, ‘Oh, I hang out occasionally with this NPC who remembers me and who I have this conversation with.’” --Mitu Khandaker

• Infinite content creation
  • Worlds, quests, art, …
  • Interactive with user preferences / guidance
Natural Communication

• **Body language**
  • Explicit gestures
  • Subtle emotions

• **Voice control**

• **Haptic feedback**

• **Brain interfaces?**
  • *natural???
How do you see the future?