

# GPU PROGRAMMING FOR VIDEO GAMES

## Introduction



Prof. Aaron Lanterman

School of Electrical and Computer Engineering

Georgia Institute of Technology

# Games are “serious business”

- Facts from [www.esa.org](http://www.esa.org):
  - \$7.4 billion revenues in 2006
  - Average player is 33 years old and has been playing for 12 years
  - 36% percent of American parents play computer
  - 80% percent of gamer parents play with their kids
- From Blizzard press release:  
World of Warcraft surpasses  
10 million subscribers in January 2008
  - \$13 to \$15 monthly (for 2.5 million in U.S. at least)
  - **Do the math!!!**



Screenshot from  
[www.worldofwarcraft.com/burningcrusade/imageviewer.html?images/screenshots/,65,241](http://www.worldofwarcraft.com/burningcrusade/imageviewer.html?images/screenshots/,65,241),

# Our GPU class fills an industry need

“CPU/GPU programming skill is the biggest hole they have. They can't find students who can do it well.”



- Prof. Blair MacIntyre

# The realities of real-time

- The architectures we will look at are driven by real-time constraints
  - 60 frames per second
  - $1/60 \approx 16.7$  milliseconds
  - Average performance is irrelevant; **it's the minimum that matters**
- In contrast, most scientific applications can be handled “offline”
  - Computers historically designed to work well in “batch mode”

# NOT a course on game design, or...

- See CS4455: Video Game Design
  - Founded by Amy Bruckman in 1998
- See CS4731: Game AI
  - But we may dabble in AI just a little bit
- Also won't be talking about...
  - “Alternative” controllers
  - Networking issues (LAN parties, MMORPGs, etc.)
  - Prototyping, user testing
  - Societal impact of games
  - Gender and games
  - Business issues (organizational issues of large teams, etc.)
- May incidentally touch upon some of the above issues

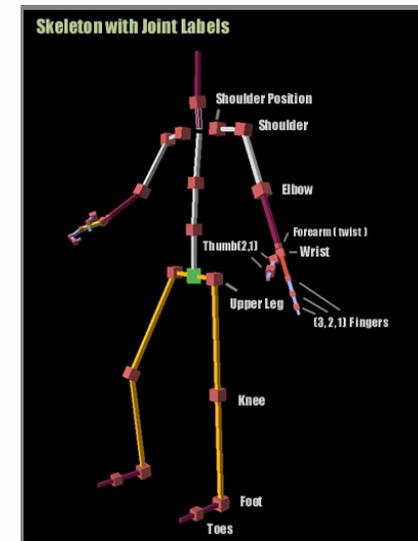


# Only partially a graphics course (1)

- No background in computer graphics required!
  - Make sure class is accessible to ECE majors
- We will review a minimal amount of necessary background
  - Geometric transformations, backface culling, clipping, rasterization, lighting, texture mapping, etc.
- Emphasis will be on real-time graphics

# Only partially a graphics course (2)

- We won't be talking about things like...
  - Perception
  - Global illumination: ray tracing, radiosity, photon mapping
    - Although people are putting such algorithms on GPUs!
  - Advanced animation techniques: inverse kinematics
- See
  - CS3451/CS6491: Computer Graphics
  - CS4496/CS7496: Computer Animation
  - CS4475: Computational Photography
  - CS4480 Digital Video Special FX



# This is **WILL** be a course on...

- Emphasis will be on games that simulate and depict “realistic” animated 3-D environments
  - Algorithms
  - Architectures
  - Programming paradigms
- Practical target platforms
  - Windows/PC/Linux with decent GPUs
  - “Steam boxes”
  - Playstation 4, Xbox One, Wii U
  - Maybe mobile platforms (phones, tablets, etc...)



# Then vs. Now

- In the early days of computer games, the “designer” and the “programmer” were often one and the same
- Nowadays there are usually separate positions of “producer,” “lead designer,” “lead artist,” “lead programmer,” etc.
- Rise of the “indie scene,” and new tools and infrastructure (Unity Asset Store, for example), are moving things back the other way

# Commercial game industry is brutal

- Nov. 2004: “EA Spouse” post (ea-spouse.livejournal.com) lead to \$14.9 million award for unpaid overtime



Erin Hoffman

- Some companies get hundreds of resumes per week per listing ([www.gamasutra.com/features/20050711/mcshaffry\\_01.shtml](http://www.gamasutra.com/features/20050711/mcshaffry_01.shtml))

Photo from Wikipedia

# Computer Engineering

- Gaming drives technological developments
- Game development experience gives future computer engineers insight
- Maybe you'll work for NVIDIA or ATI?
- Maybe you'll work for Intel, AMD, or IBM?
- Maybe you'll help design the Playstation 5, Xbox Two, or Wii Whatever?

# Think “outside the box”

- “Game” programming/design: think beyond the commercial industry
- Scientific potential of GPGPU
- Even if you never program any “games,” **parallel processing is the future**
- That all said - we’d be totally thrilled if you got a job at Insomniac, Bungie, Blizzard, Valve, Bethesda, BioWare, etc.

# Many opportunities for indie developers (1)

- On-line distribution takes manufacturing costs out of the equation
- “Brick & mortar” stores have limited shelf space
- Services like Amazon, Netflix, etc. can exploit “the long tail”
- Why are we still shipping boxes mostly full of air?



Photos from <http://cribbster.wordpress.com/2009/01/27/>

## Many opportunities for indie developers (2)

- Jeff Vogel of Spiderweb Software
  - Old-school RPGs
  - Exile, Nethergate, Avernum, Geneforge
  - [www.spiderwebsoftware.org](http://www.spiderwebsoftware.org)
  - Makes house payments, feeds kids



From  
[www.spidweb.com/misc/jvogel.html](http://www.spidweb.com/misc/jvogel.html)

# Consoles hostile territory for indie devs (1)

- To sell games on a console, you still must pass the gatekeepers at Sony, Microsoft, and Nintendo
- Code must be “digitally signed” to run
  - Piracy concerns
  - Consoles supposed to provide safe environment
    - Unlike PC users who are used to dealing with viruses, spyware, crashing programs
    - Manufacturers worried about “untrustworthy” code screwing up people’s consoles
    - Want to ensure a uniform, “quality” experience
- **They have more lawyers than you**

## Consoles hostile territory for indie devs (2)

- Nintendo NES “pioneered” business model
  - Typically sell consoles at a loss
  - Charge royalty on units **manufactured**, not units sold
- For indie developers, online distribution (Xbox Live Arcade, Playstation Network, WiiWare, etc.) seems like the least risky option
- Xbox 360: XNA Indie Games
  - Alas, didn’t “catch fire”

# “PC” friendly territory for indie devs?

- Well-established distribution networks like Steam, Good Old Games, etc.
- Can also sell on your own website
- Dark side: difficulty of supporting endless processor/chipset/GPU/OS etc. combinations



# “Mobile” friendly territory for indie devs?

- Distribution networks like Apple’s App Store and Google Play
- Dark side: saturated market leads to “race to the bottom” leads to low profit margins



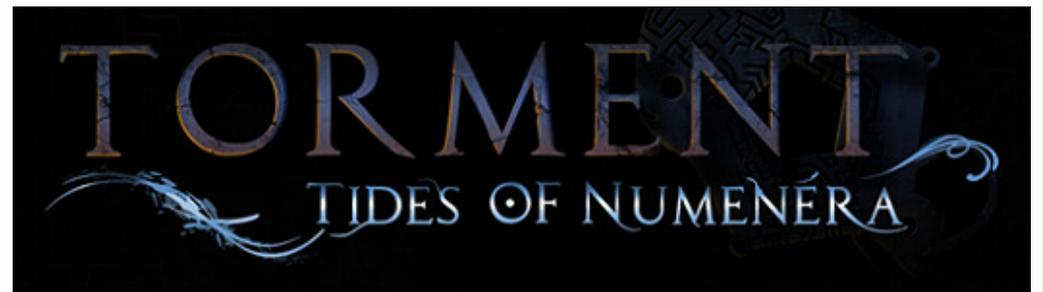
Google play

# Crowdfunding (1)

- Kickstarter, Indiegogo, etc.
- Some high profile successes



Shroud of the Avatar  
Forsaken Virtues



# Crowdfunding (2)

- Some high-profile not-successes



# “Serious Games”

- Games for “training” and “education”
  - First responders: “Hazmat: Hotzone”
  - Medicine: “Pulse!!”
  - Business: “Stone City” for Cold Creamery



- Ian Bogost (LMC) doesn't like the term “serious games”

Screenshots from

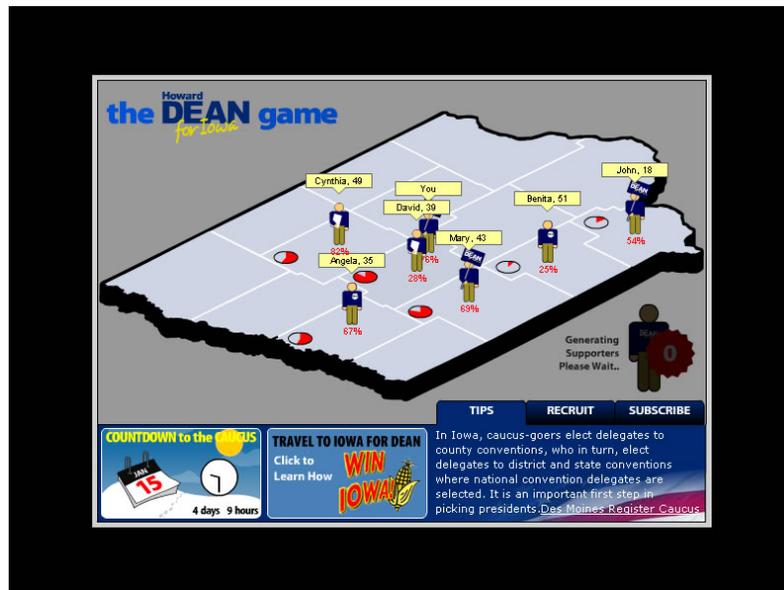
[www.gamasutra.com/features/20051102/carless\\_01b.shtml](http://www.gamasutra.com/features/20051102/carless_01b.shtml)

[www.businessweek.com/innovate/content/apr2006/id20060410\\_051875.htm](http://www.businessweek.com/innovate/content/apr2006/id20060410_051875.htm)

[www.persuasivegames.com](http://www.persuasivegames.com)

# “Persuasive Games” & “Games for Change”

- Expand the “Serious Games” notion to include broader categories like “advertising,” (advergame), “propaganda,” “subversion”
- The Howard Dean for Iowa game
- Disaffected! (not authorized by Kinkos)

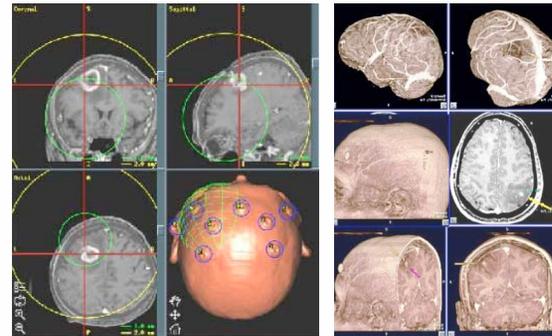


Pics from [www.persuasivegames.com](http://www.persuasivegames.com)  
Info from Ian Bogost, “Persuasive Games”

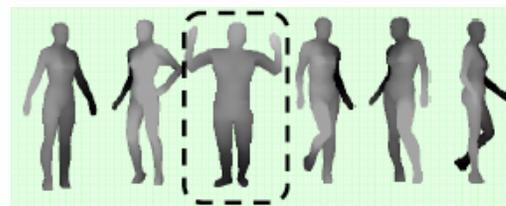
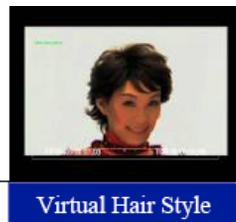


# Other real-time applications

- Graphics
  - MRI in the operating room
- Processing
  - Machine vision



- Toshiba demos: real-time face tracking, markerless motion capture, hand gesture user interface



- Data compression/decompression
  - Toshiba HDTVs with Cell processors
- Radar signal processing
  - 7 SPE Cells -> PS3s; 8 SPE Cells->Mercury Computing blades

Images from [sti.cc.gatech.edu/Slides/Masubuchi-070618.pdf](http://sti.cc.gatech.edu/Slides/Masubuchi-070618.pdf)  
and <http://www.radiology.uiowa.edu/NEWS/Haller-PDF.pdf>

# Hollywood

- Final ray-traced renderings usually done off-line using “render farms”
- Continually improving real-time graphics lets moviemakers more easily experiment via “pre-viz”
  - Both on CGI-intensive sequences and live-action sequences

[http://www.youtube.com/watch?v=iaVj\\_Q0dkCc](http://www.youtube.com/watch?v=iaVj_Q0dkCc)

# Machinima – filmmaking with game engines



Michael Nitsche (LMC)

Rooster Teeth's Red vs. Blue  
From [www.spectrum.ieee.org/computing/hardware/machinimas-movie-moguls](http://www.spectrum.ieee.org/computing/hardware/machinimas-movie-moguls)



# Game engine competition FTW



**UNREAL  
ENGINE**



**CRYENGINE 3**

