

Additional Topics:

Computing Principles and Practice
of a
Blockbuster Video Game

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The Walt Disney Company

Split/Second: Velocity

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Video Game Industry

- Digital Economy
 - Creative Industries
 - Growth
- Retail Delivery
 - Developing online
 - Convenience



- Blockbusters

- Modern Warfare £111m US
- Grand Theft Auto IV £108m GB (2008)
- FIFA £58m CAN
- Wii Fit £45m JPN
- Assassin's Creed £36m CAN
- Need for Speed £18m GB
- Batman £15m GB [\(2009/2010 UK sales source Develop 100\)](#)

gamedevmap.com

Industry Trends

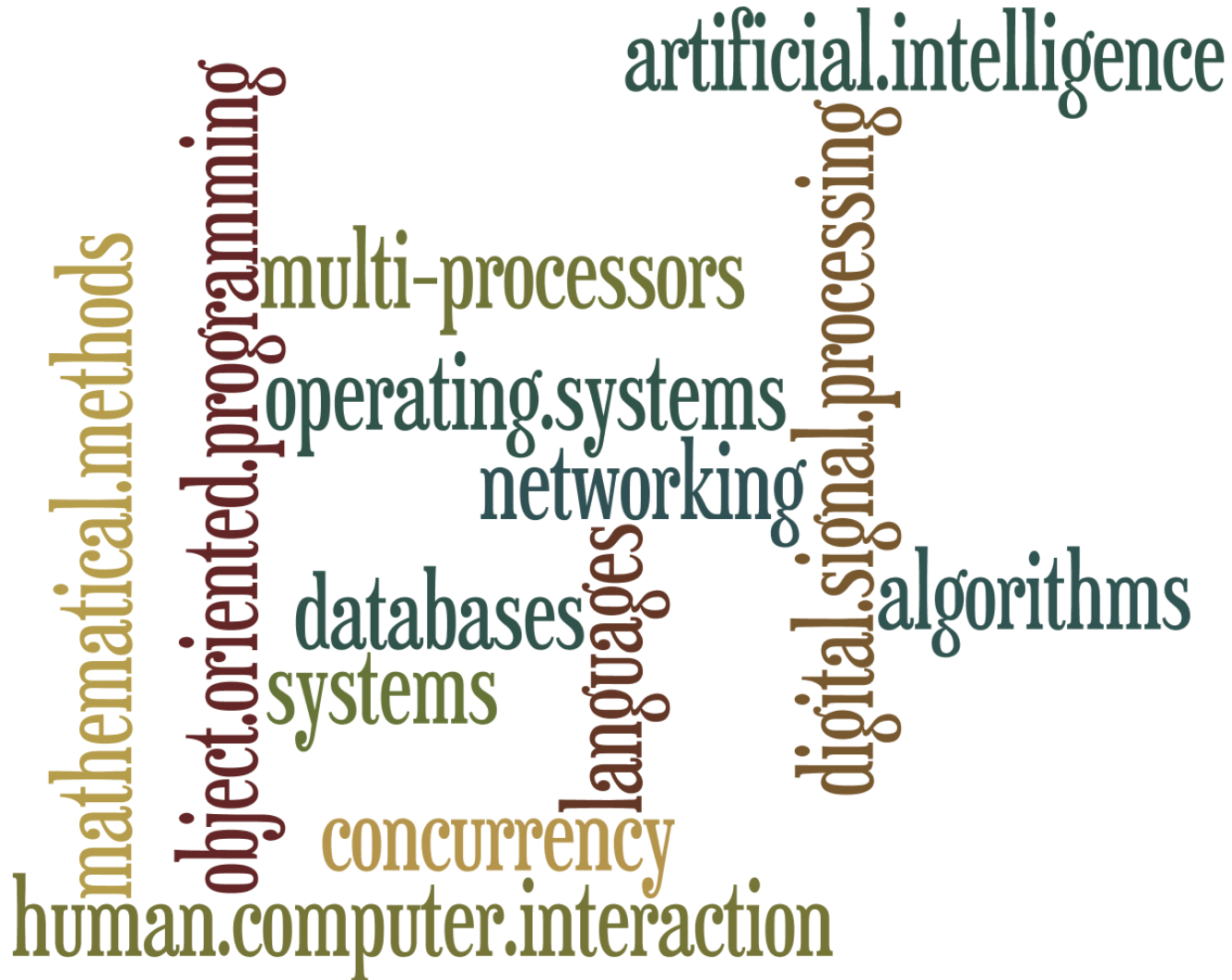
- Data in cloud, persistence, levelling-up
- Episodic and user generated content
- Simple natural interfaces
- Hyper-realism
 - Photorealistic, stylised
 - Can machines simulate interactive reality?



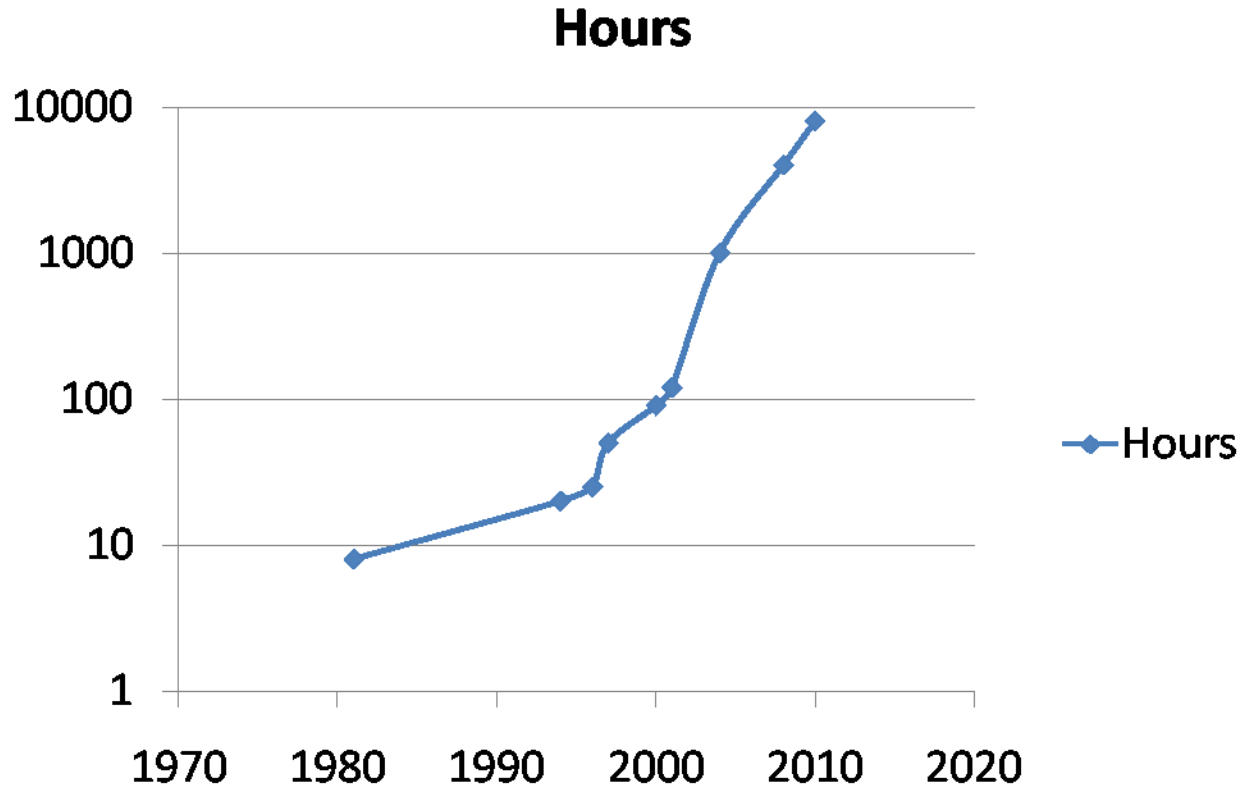
Real-time

- Define
 - 10hz : Interactive
 - 24hz : Film
 - 30hz : Games
 - 60hz : High refresh rate critical games
 - 120hz : High quality 3D stereoscopic games
 - Needs to be constant, no spikes to break immersion
- Input
- Latency

Game Development



Programmer Development Time



- Exponential increase in programming time per game

game:

Language	files	code
C++	2187	345040
C/C++ Header	2375	111023
XML	104	47277
Python	205	12607
HTML	2	6256
ActionScript	35	5072
C#	9	785
DOS Batch	20	172
Bourne Shell	6	126
MSBuild scripts	1	74
SUM:	4946	528445

Code

Tools+Pipeline: Python

Runtime: C++

Shaders: CG, HLSL, ASM

libraries:

Language	files	code
C++	1961	295523
C/C++ Header	2408	148015
HTML	243	64380
Python	96	5060
Lua	75	5060
C#	11	4871
XML	76	2178
C	1	2150
Bourne Shell	9	1008
DOS Batch	35	383
MSBuild scripts	1	290
CSS	1	145
Teamcenter def	1	11
SUM:	4918	524017

utils:

Language	files	code
Python	372	36345
C++	76	16487
Perl	26	3503
C/C++ Header	58	2467
HTML	75	1580
XML	12	1165
C#	10	1078
C	3	419
Bourne Shell	12	329
Javascript	2	303
Java	2	291
PHP	2	234
Visual Basic	2	176
SUM:	664	64771

ld:

Language	files	code
Bourne Shell	21	27517
C/C++ Header	89	8196
C	4	7169
HTML	16	6567
Python	26	2554
DOS Batch	6	1218
yacc	2	503
CSS	1	410
Assembly	9	387
C++	5	230
make	5	191
Lisp	1	163
SUM:	316	102081

tools:

Language	files	code
C++	1782	328364
C/C++ Header	1928	92168
HTML	29	3379
Python	23	2984
XML	22	1738
C	4	948
C#	4	345
MSBuild scripts	1	180
Bourne Shell	11	169
make	6	75
Teamcenter def	12	64
Perl	1	55
IDL	1	34
DOS Batch	13	27
SUM:	3837	430530

Team Size

- Doom (1993)
 - ~10 developers
- Harry Potter (2005)
 - ~70 developers
 - Brook's vs "Potter's" law
- Split/Second (2010)
 - Peak ~150 dev staff
 - Outsourcing
 - Short term contracts



Courtesy Michael Carr

Methods

- AGILE
 - Small focused teams, responsive to changes
- Wiki use
 - Efficient communication portal between teams
 - Tasks, blogs, reports
- Automated testing infrastructure
 - Test driven development
 - Unit tests
 - Continuous code & asset builds validating content
 - Render & profiling deviation tests

Stages

Pre-production

1. Art style, x-movie, R&D, proof of concept
2. Tools production, mature pipeline, vertical slice build

Production

1. Large art/design/outsourced content team
2. User testing and feedback
3. Optimization, polish, quality assurance testing

Post-production

- n. Downloadable content (DLC), community, patch

Platforms

- Focus
 - Relatively aligned
 - Outsourced ports



Platform	Xbox 360	Playstation 3
CPU	3.2 GHz 3 CPU 2 threads each	3.2 GHz 1 Core (2 threads) + 6 SPUs
GPU	shader model 3	shader model 3
Main RAM	512 MB	256 MB
Bandwidth	21.2 GB/s	25 GB/s
VRAM	10 MB (E)	256 MB
Bandwidth	256 GB/s	25 GB/s

Bottlenecks

- Build
 - Code, Assets, Live Update
- Memory
 - Media, RAM, VRAM
- Simulation
 - AI, animation, physics
- Rendering
 - Geometry
 - Shading

Not Bottlenecks (unless...)

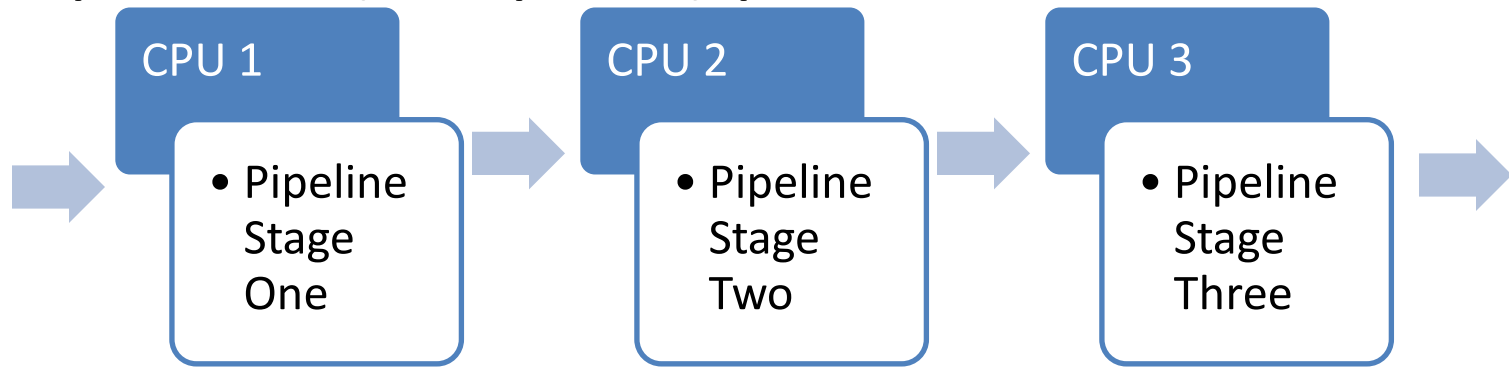
- Game logic, control, progression
 - Increasing to 1000s of entities
- Simple joypad input
 - Image processing, skeletal tracking, biometrics
- Audio
 - Speech recognition, synthesis, voice location

Optimization

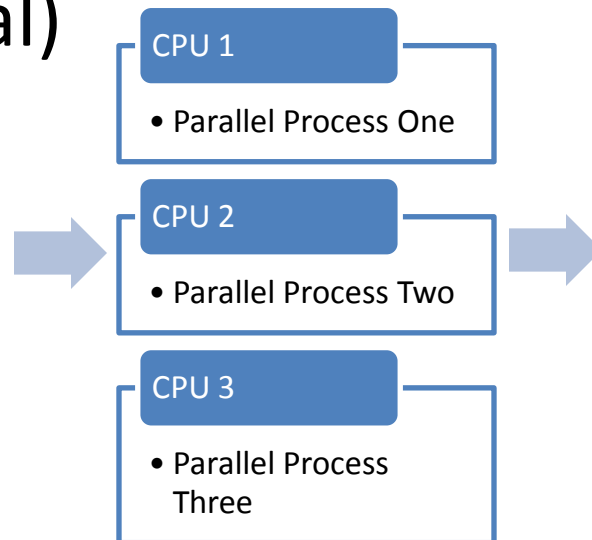
- Knuth/Hoare
 - ‘Premature optimization is the root of all evil’
- ‘Moore’s law is dead’, [Gordon Moore](#)
 - Increase use of parallelism to multi-core and many-core
- Amdahl’s law
 - Parallel speed up is limited by sequential portion of process
- Gustafson’s law
 - Sequential portion relatively small when massively parallel

Pipelining

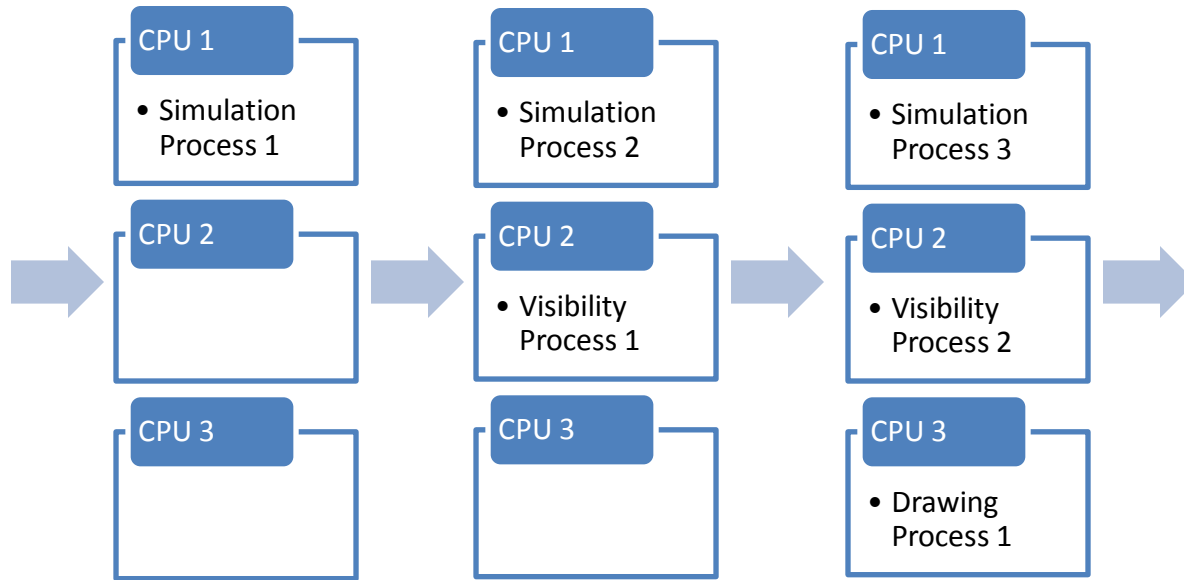
- Pipelined (temporal) parallelism



- Parallel (spatial)



Pipelined Game Processing



- Increases throughput, but introduces latency

Latency

- Stages of an interactive loop
 - Player
 - Sensory impulses -> reaction time -> motor control
 - Input
 - Physical input -> device capture -> signal process
 - Simulation
 - Interpret input -> compute response -> update state
 - Render
 - Dispatch drawing commands -> video signal -> display lag
- 1 to 5 frames depending on
 - Required responsiveness
 - Device and hardware characteristics

Elements of a Blockbuster

- Shading
- Lighting
- Physics
- Particle
- Cameras
- Speed

Car Shading

- 2 Tone Paint
 - Fresnel
 - Clear coat
 - Dynamic reflection
- Damage
 - Smoke
 - Lacquer scratches
 - Scrapes
 - Glass



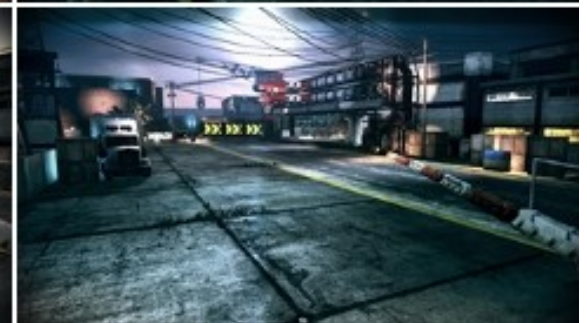
Lighting

- Deferred Shading
 - Reduces per-pixel shading cost to only visible surfaces
- First Pass
 - G-Buffer
- Shading Pass
 - Dynamic
 - Many lights



Lighting

- Rigs
 - Day
 - Night



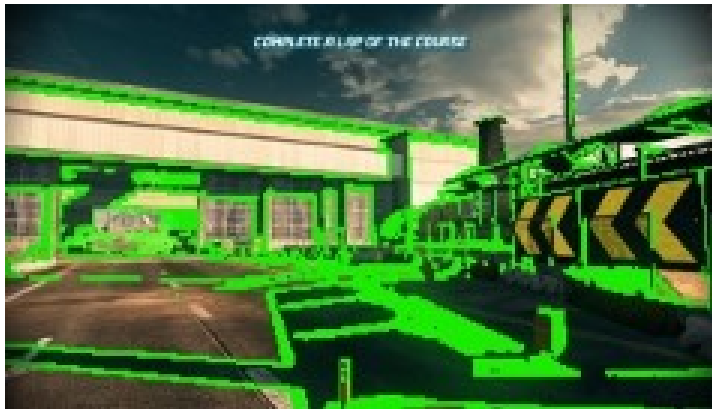
Lighting

- Some lighting elements baked offline
 - Static global illumination
 - Too costly to compute (our R&D work)



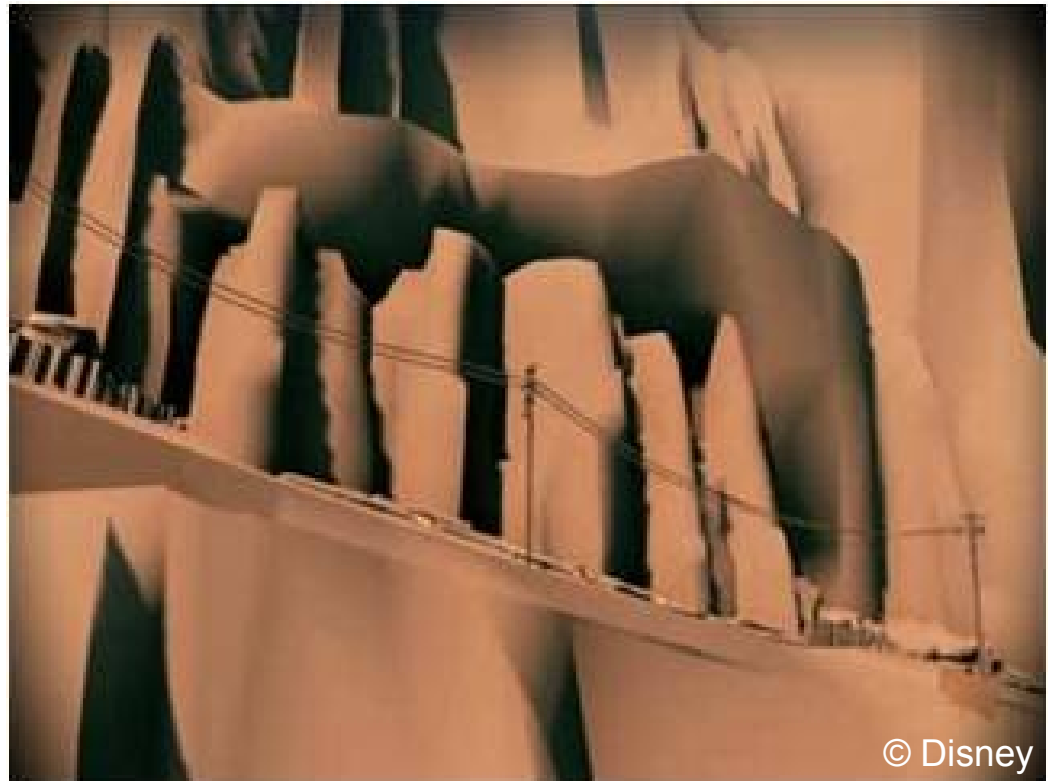
Lighting

- Tiled classification of image elements permits reduced shading cost
 - Soft shadow edge filtering
 - Geometry edge anti-aliasing



Rock Blast

- Grey box
- Prototype simulation
- Billboard particles



Rock Blast

- Textured
- Validate fracture visuals



Rock Blast

- Apply particle effects



Rock Blast

- Combine with environment



Rock Blast

- In game
 - Debris away from track, interactive boulders, particles



Particles

- Non-interactive particles add to the visual composition



Interactive Physics

- Distorting particles
 - Apply turbulence force of volume displaced by cars



Rubber Neck Camera

- Accentuate highlights with bullet time camera zoom



3 Way Track Changes

- Destructive events change track layout
 - Updating AI car paths and collision geometry



1.5Km of Destruction

- 1000+ animating joints processed in parallel on SPUs



1.5Km of Destruction

- Pushing the edge of floating-point precision for collision volumes



Velocity



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Questions?

- Thanks to the Black Rock Studio Team



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