Game Technology

Lecture 11 – 16.01.2015

Dipl-Inf. Robert Konrad
Dr.-Ing. Florian Mehm

Prof. Dr.-Ing. Ralf Steinmetz
KOM - Multimedia Communications Lab

Preliminary timetable

TECHNISCHE UNIVERSITÄT DARMSTADT

Lecture No.	Date	Topic
1	17.10.2014	Basic Input & Output
2	24.10.2014	Timing & Basic Game Mechanics
3	31.10.2014	Software Rendering 1
4	07.11.2014	Software Rendering 2
5	14.11.2014	Basic Hardware Rendering
6	21.11.2014	Animations
7	28.11.2014	Physically-based Rendering
8	05.12.2014	Physics 1
9	12.12.2014	Physics 2
10	19.12.2014	Procedural Content Generation
11	**16.01.2015**	**Compression & Streaming**
12	23.01.2015	Multiplayer
13	30.01.2015	Audio
14	06.02.2015	Scripting
15	13.02.2015	AI


STEALTH-COM

Today‘s Games

Typical hardware requirements

- 8 GiB RAM
- 2 GiB Video-RAM
- 50 GiB on disk

All SNES games ever (including all language versions)

- ~3000 games
- ~4.5 GiB

Today‘s Data

One uncompressed texture

- 4096 x 4096 x 4 Bytes = 67108864 Bytes = 64 MiB
- 2 GiB / 64 MiB = 32
- Physically based rendering – typically 4 textures

Killzone 4 CPU data

TECHNISCHE UNIVERSITÄT DARMSTADT

Sound	553 MB
Havok Scratch	350 MB
Game Heap	318 MB
Various Assets, Entities, etc.	143 MB
Animation	75 MB
Executable + Stack	74 MB
LUA Script	6 MB
Particle Buffer	6 MB
AI Data	6 MB
Physics Meshes	5 MB
Total	**1,536 MB**

Killzone 4 GPU data

Non-Steaming Textures	1,321 MB
Render Targets	800 MB
Streaming Pool (1.6 GB of streaming data)	572 MB
Meshes	315 MB
CUE Heap (49x)	32 MB
ES-GS Buffer	16 MB
GS-VS Buffer	16 MB
Total	**3,072 MB**

PNG and JPEG

PNG

- Lossless
- Compression highly dependent on image content

JPEG

- Lossy
- Generally strong compression

Both

- Slow decompression
  - Can slow down loading times
- Not possible to access a single pixel while compressed
  - Not usable for image computations
    aka not usable as a texture format

Texture Compression

Many different formats

- S3TC, PVRTC, ASTC,…
- Has to be supported by GPU and Graphics API
- Of course much of it is patented and hard to standardize

Design goals

- High compression
- Low visual degradation
- Efficient single pixel access
  - Constant size of a pixel or a pixel block

Possible compression strategies

Less than 8 bits per color might be ok

The eye‘s color resolution is less then its intensity resolution

Neighboring pixels likely have similar colors

Example 1

ETC

- Ericsson Texture Compression

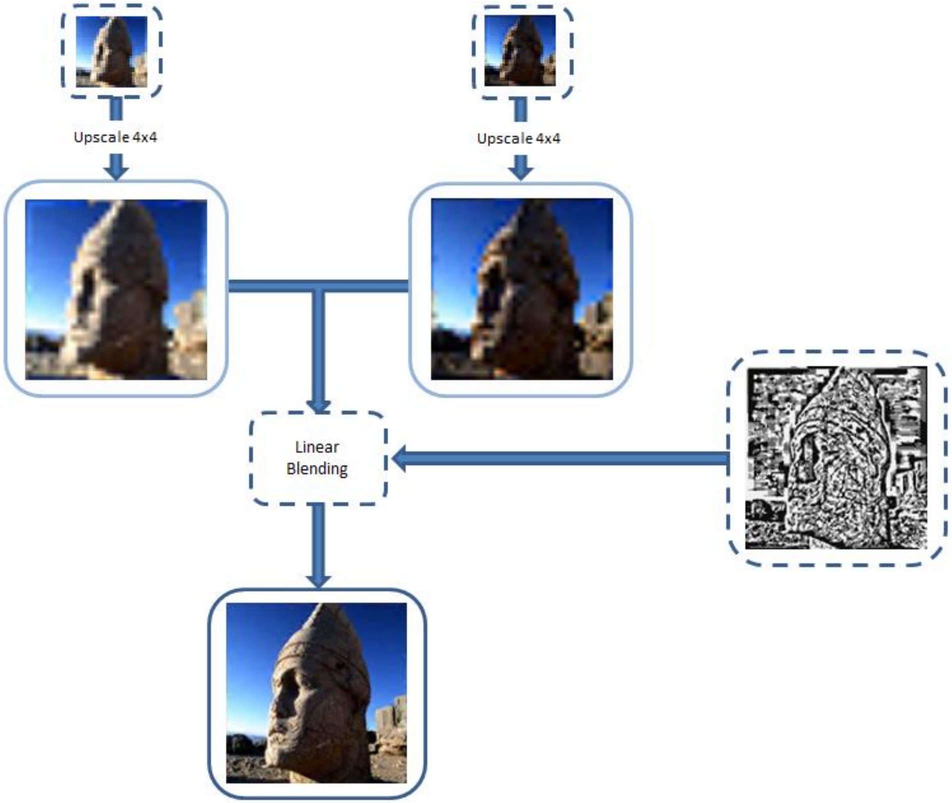
Compresses 4x4 pixel blocks to 64 bits

- Split into two 2x4 groups
- Each gets a 12 bit base color plus 3 bit brightness range selection
- Each pixel gets a 2 bit offset value

Example 2

PVRTC

- PowerVR Texture Compression



Normal Maps,…

TECHNISCHE UNIVERSITÄT DARMSTADT

Compression for images might not be optimal for other textures

- But it might just work
- Swizzling channels can help

3Dc

- $x^2+y^2+z^2=1$
  - $z^2=1-x^2-y^2$
  - One value can be omitted
- Plus block compression

Manual Compression

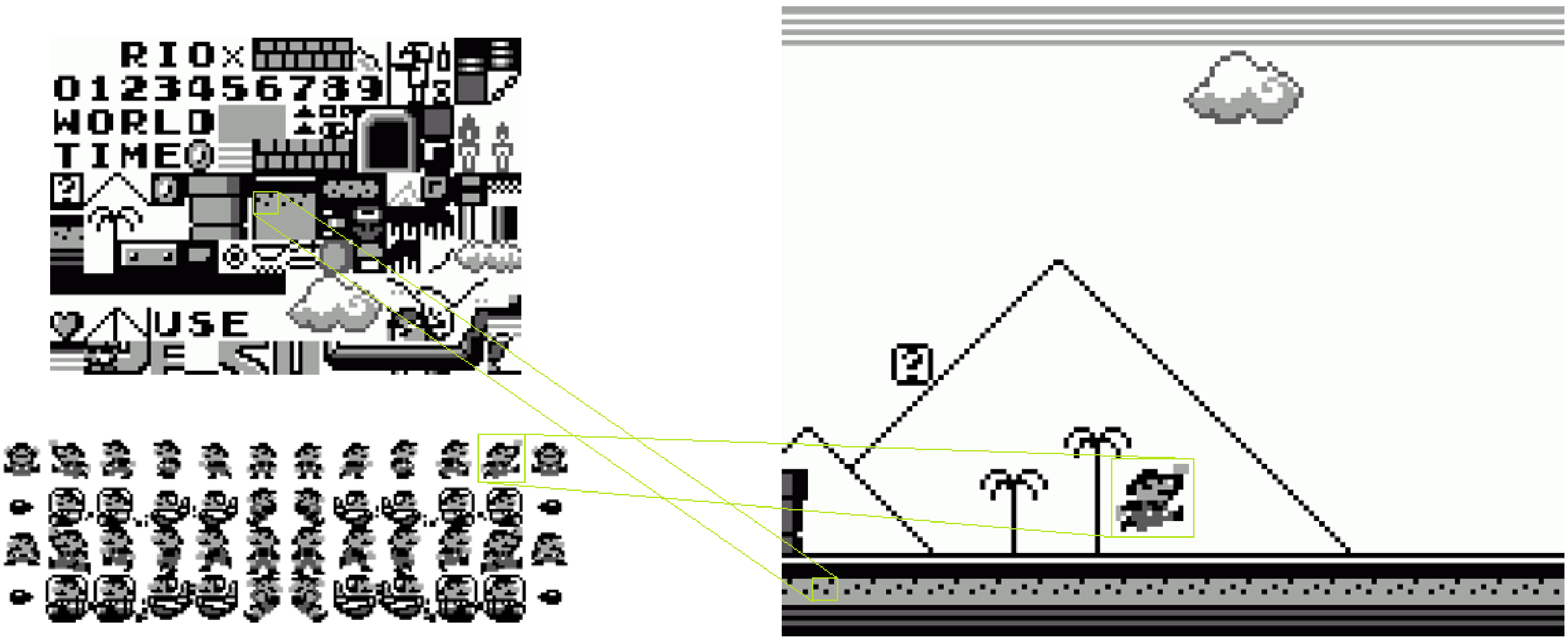
TECHNISCHE UNIVERSITÄT DARMSTADT

Let the artists do the job

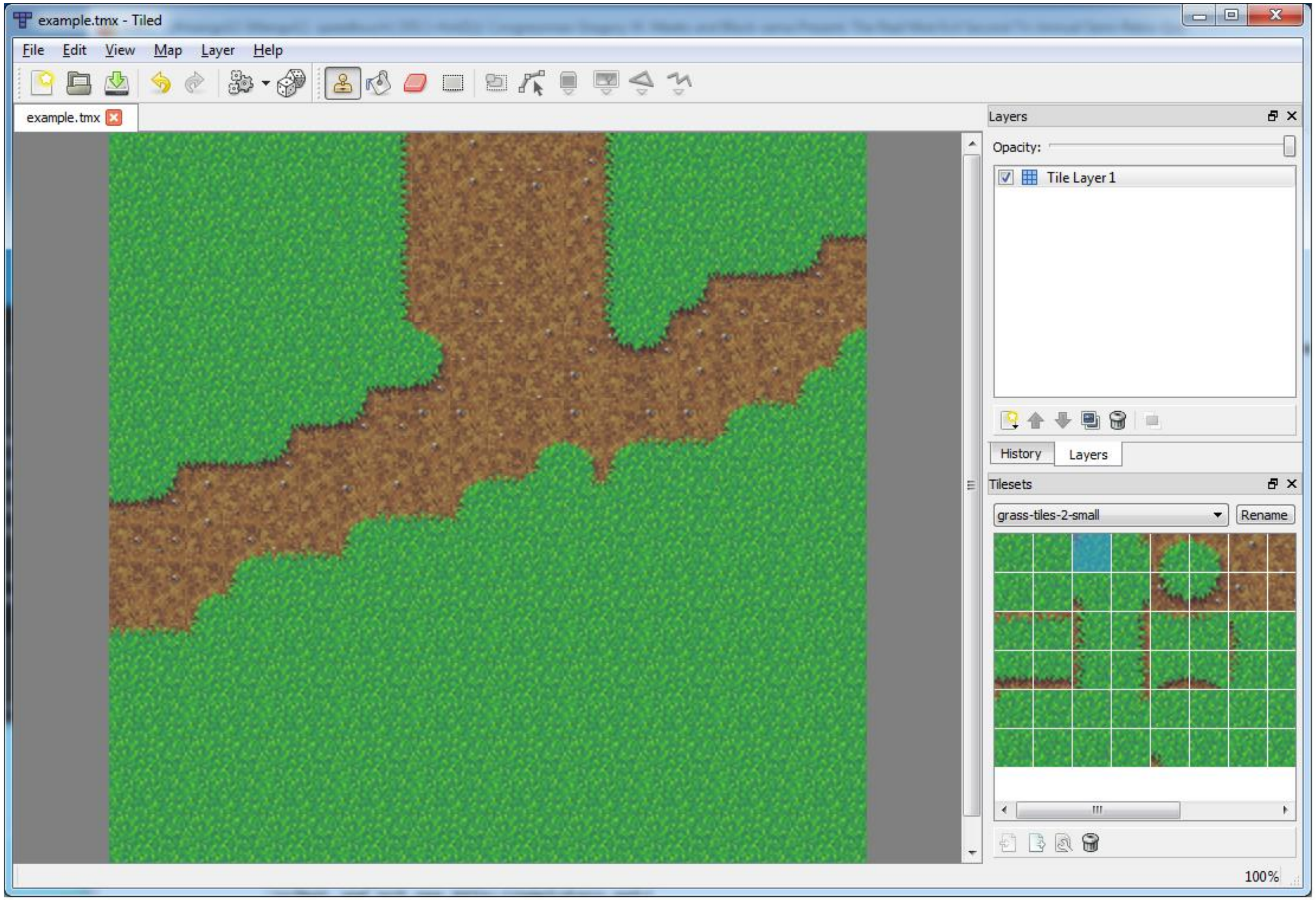
Repeat images over and over

- Nobody might notice it when you do it cleverly

Tilemaps/Tilesets



Tile Editors



Pitfall: The Mayan Adventure

Warcraft 3

Tilemaps in 3D

Bilinear Filtering

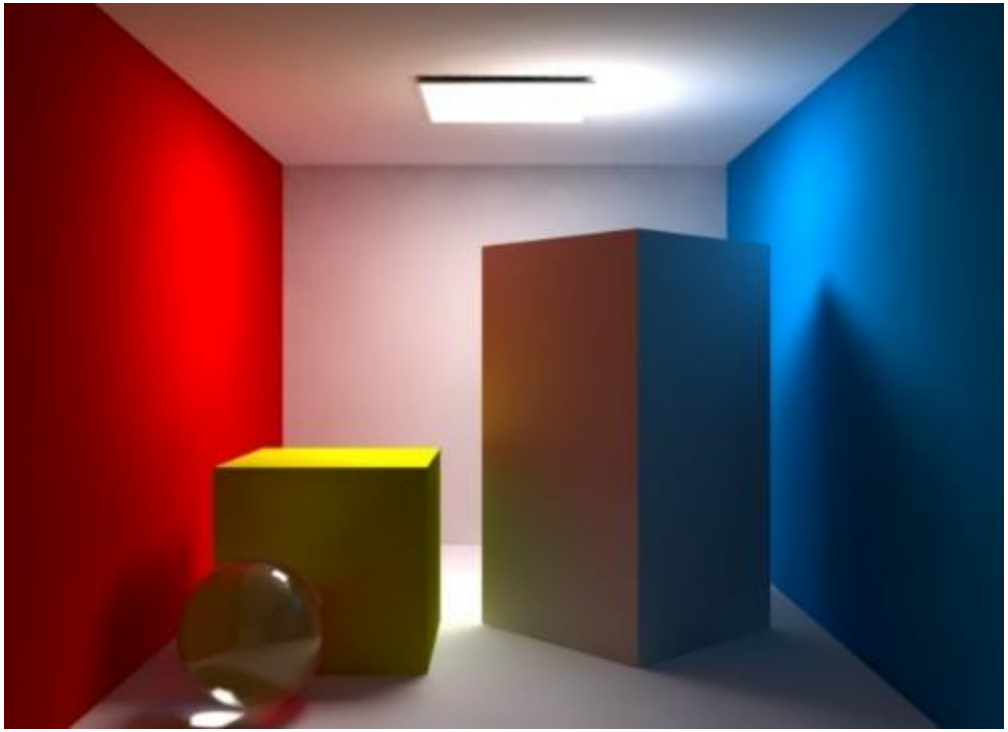
- Would have to use texels from two tiles at tile boundaries
- Complicated
- Expensive
- Rarely used

Multitexturing

Multitexturing

Multitexturing

Good lighting can hide a lack of details



Problems

Performance

- More textures, less performance
- Precalculating which polys actually use more textures can help

Needs good tool support

- Scary communication with artists

Streaming

Coarse Streaming

- Load and replace complete assets

Fine Grained Streaming

- Load and show/play a single asset bit by bit

Coarse Streaming

Similar to level of detail systems

- Load big textures for near objects
- Kick out big textures for far away objects
- Maybe blend texture changes in and out

SWIV

Problems

TECHNISCHE UNIVERSITÄT DARMSTADT

Disks are slow and unreliable

- No timing guarantees at all
- Load textures in a second thread,
  always have an emergency strategy ready
  (keep super low resolution textures of everything in RAM)

Changing textures at runtime is problematic

- Driver might decide to convert the texture
- Easier on console
- Probably easier with Direct3D 12

Fine grained texture streaming

TECHNISCHE UNIVERSITÄT DARMSTADT

MegaTextures

Really huge textures

- Rage supports textures of up to 128000×128000
  - That‘s ~60 GiB

Compression

- Texture is highly compressed on disk
  - Using lossy JPEG like compression

One texture for everything

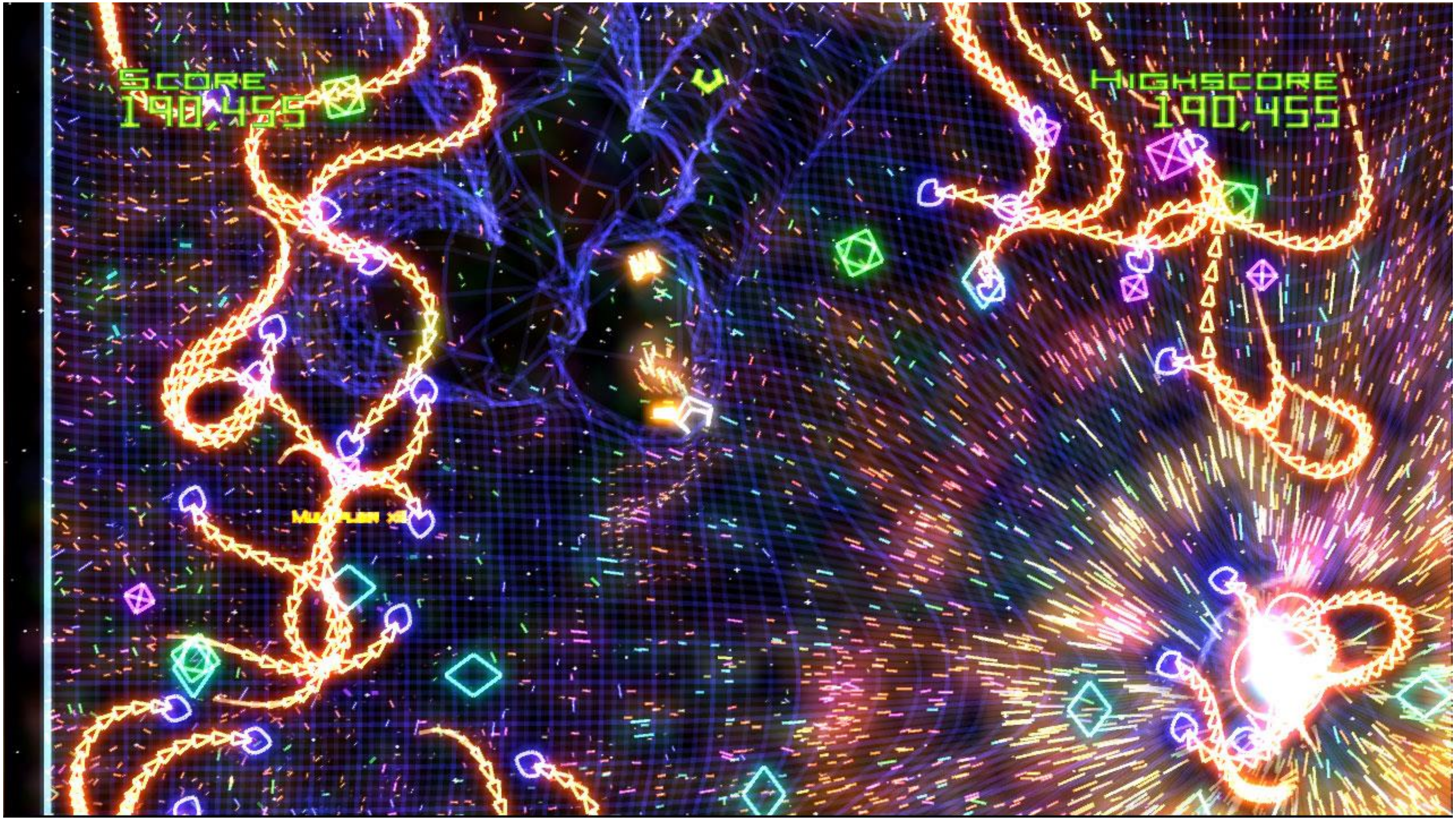
- Complete world in one texture
- No restrictions for artists
  - But toolsets provide classical multitexturing tricks
  - Artists don‘t manually paint 128000x128000 pixels

MegaTextures

Geometry is split up in tiles

- Engine determines screen size of visible tiles
- Loads texture parts in varying sizes to optimize current view

Geometry



Geometry Compression

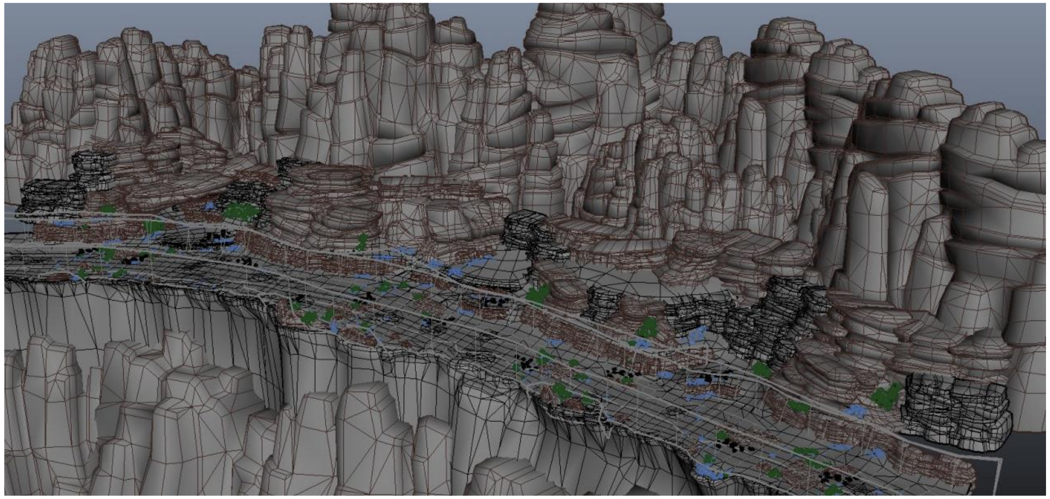
Not widely used

No hardware support

Special strategies for animations

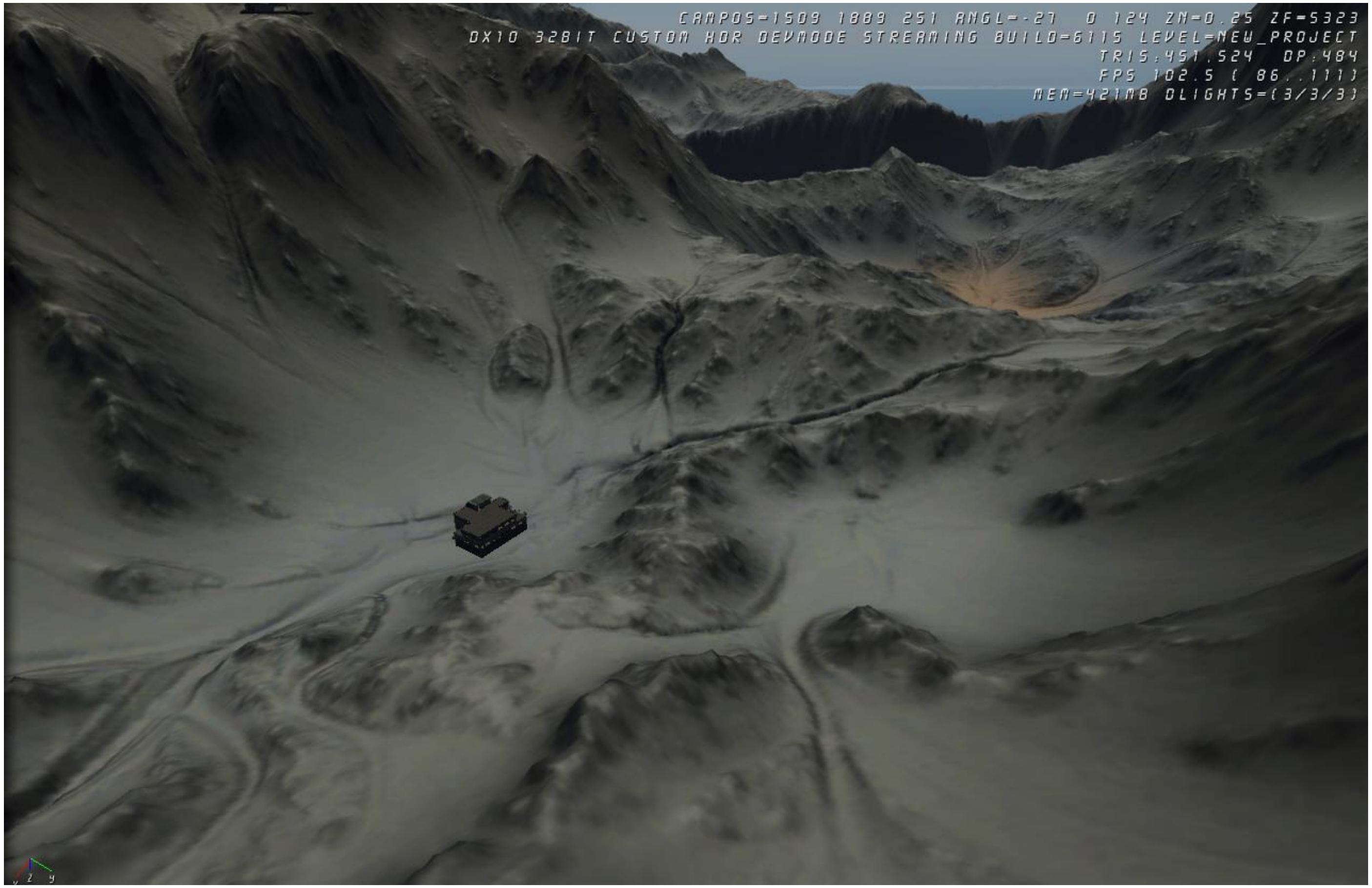
- Like skeletal animations, which are tiny

Manual Compression



Height Maps

Just Y instead of X/Y/Z



Normal Maps

Remove super detailed geometry

Replace with normal maps

- Which is a form of compression by itself
- Plus normal can be further compressed

Coarse Geometry Streaming

TECHNISCHE UNIVERSITÄT DARMSTADT

Same strategies as for textures

- Could be directly plugged into a level of detail system

Fine grained geometry streaming

To be done

Sound

mp3 and similar compressed formats

- Nothing special – at least not anymore

Coarse streaming for sound effects

- Easy
  - Sound effects are short
  - Sound effects don’t stay on screen
  - Sound effects can stay in CPU RAM

Fine grained streaming for music and maybe speech

- Even mp3 players do it

Really Big Worlds

TECHNISCHE UNIVERSITÄT DARMSTADT

32 bit floats

- "total precision is 24 bits (equivalent to $\log_{10}(2^{24}) \approx 7.225$ decimal digits)"
  - Can be a little tight for big worlds

Use 64 bit floats for positions

- Hard to integrate 32 bit physics engines

Split and Shift the world

- Split the world
- Shift the closest parts to a position nearer at the camera

Profiling

TECHNISCHE UNIVERSITÄT DARMSTADT

Sampling

- Samples at random intervals
- Does not modify code

Instrumentation

- Adds sampling code to binary

Performance Counters

CPU integrated circuitry that measures certain performance characteristics

- Like number of cache misses,…

Can be read by CPU specific profiling tools

Task 2.1

We are trying to find a „non-convex hull“ of the points of the cities

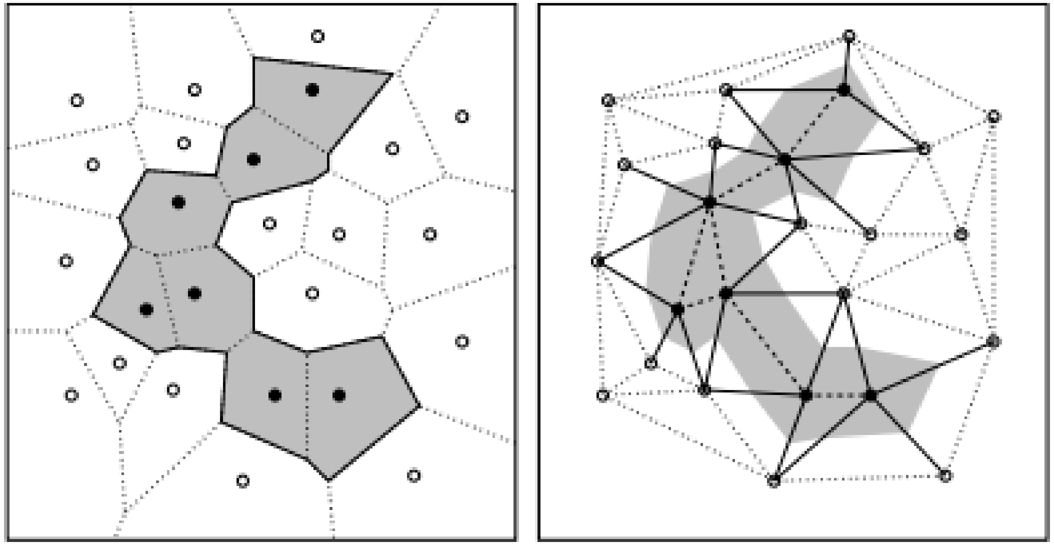
A regular convex hull would not approximate our mental image of a „border“ between two regions

Task 2.1

Use the cells that contain the cities and visualize those areas

Maybe blur or soften the edges to make them rounder

What about „islands“?



(a) (b)

Task 2.1

See Paper „What Is the Region Occupied by a Set of Points?" by Antony Galton and Matt Duckham for more info on the problem of "non-convex hulls" (http://www.geosensor.net/papers/galton06.GISCIENCE.pdf)

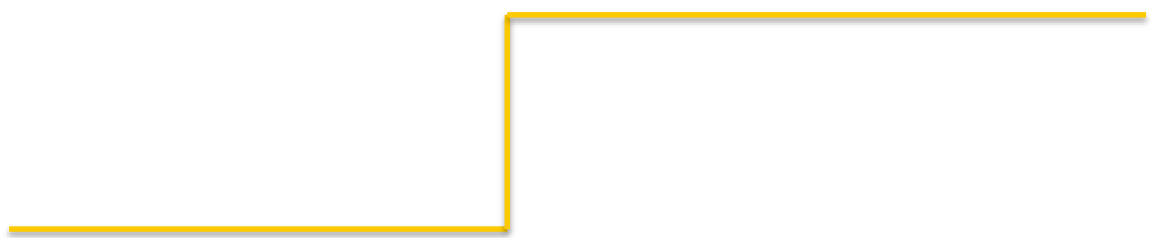
Task 2.2

Easier to see in 1D

An edge is a sudden change of function value

1D kernel:

- -1 2 -1



Task 2.2

If all three pixels are constant:

- p1 = p2 = p3 = c
- Result = -1c + 2c – 1c
- = 2c – 2c = 0

If the left pixel is different

- p1 = c1, p2 = p3 = c2
- Result = -1c1 + 2c2 –c2
- = c2 – c1

→ Constant areas of the image become black, the edges remain

Task 2.3

With larger sigma, the curve doesn‘t reach as high, becomes more stretched out

The area under the curve stays the same

→ The curve becomes wider and is therefore visibly cut off and if we use the coefficients without normalizing, they will not add up to 1

→ Without normalizing, we will change the brightness of the image