Some
Rendering Research Results

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Overview

- who is the Institute of Computer Graphics&A?
- overview of rendering projects
  - including some rendering results
- 2-3 projects in more detail

  - note: no motivation
    no related Work
    no implementation
    no summary
    no future Work !

Where we are

Institute of Computer Graphics & Algorithms

1 out of 7 institutes of the informatics faculty

2 working areas:

- **algorithms and data structures (186/1)**
  - Günther Raidl + 5 assistants
- **computer graphics (186/2)**

  2 working groups:
  - visualisation
    - Eduard Gröller
  - rendering
    - Werner Purgathofer

TU Wien Computer Graphics Group

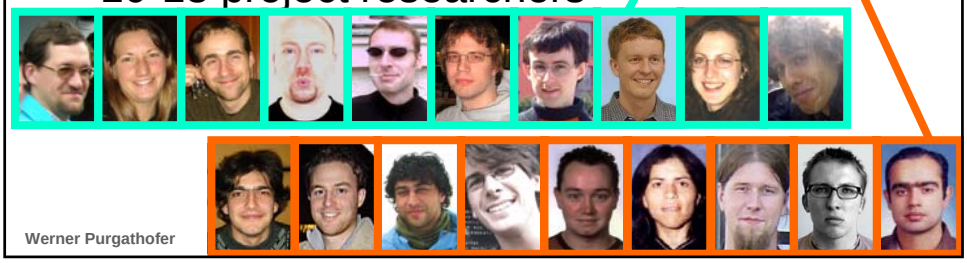
- ~ 20 - 24 people
  - 2 professors (Purgathofer, Gröller)
  - 4 - 5 research assistants
  - 2-3 secretaries / 2-3 technicians
  - ~ 10 - 14 scientists from projects
- ~ 400 m² rooms
- ~ 600.000 € project value per year

Contents and Projects

- ***Teaching and Research*** in
  - scientific and information visualisation
  - realtime rendering virtual environments
  - photorealistic image synthesis and color
- ***Research Activities***
  - Kplus-Competence Center **VRVis**
  - ~3 EU-IST-projects
  - 2 to 5 FWF-projects, ~1 FFF-Project
  - a few other projects

People at 186/2

- 2 professors
- 2-3 secretaries
- 2-3 (50%) technicians
- 4-5 assistants
- 1 student assistant
- ~ 10-18 project researchers



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People at 186/2: Nations

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Some Recent Investments

- autostereoscopic monitor
- Seminarraum improvement
- color-lab

Autostereoscopic Monitor

Seminarraum

Wern

Color Lab

Werne

Some Current Partners of the Institute

Main Projects

ILScan

TreeLumination

Physically Plausible Skylight Rendering

(plus a few other projects)

TreeLumination (FWF Project)

- Goal: display realistic trees in real time
- applications: computer games, architecture
- model interaction between light and leaves
  - reflectance
  - translucence
  - self-shadowing

- lighting a tree in a natural environment
  - sunlight
  - skylight
  - shadows

TreeLumination (FWF Project)

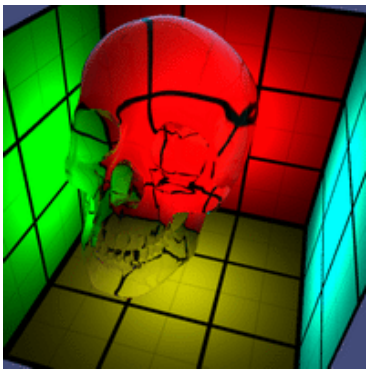
- first results

TreeLumination (FWF Project)

FWF

GameTools (EU Project)

- Goal: tools (libraries) for the game industry
- three main parts
  - geometry
  - global Illumination
  - visibility
    - online/offline



GAMETOOLS

Information Society Technologies

RealReflect (EU Project)

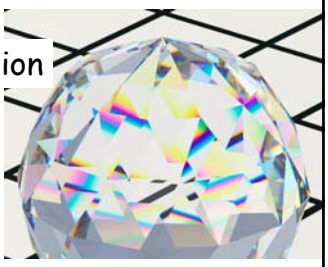
- finished in October 2005
- main goals:
  - automatic BTF acquisition and compression
  - texture mapping on arbitrary LODs
  - surface light field creation and rendering
  - accurate tone mapping

Information Society Technologies

Advanced Rendering Toolkit (ART)

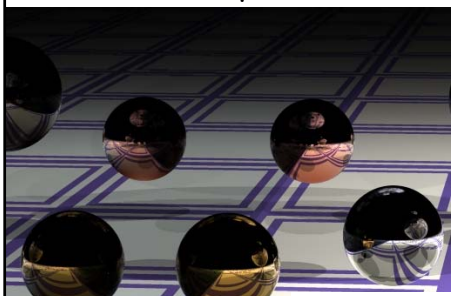
radiosity

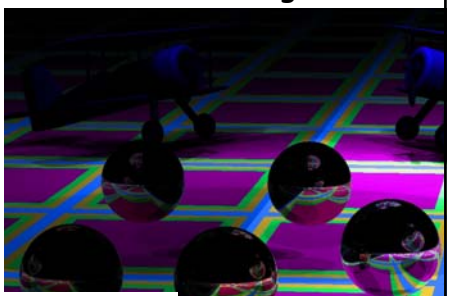
dispersion



with vertical polarisation

UV-blacklight





polarisation fluorescence

ILScan (TU Innovatives Projekt)

- 3D Laser Scanning
  - rendering huge point clouds (Ephesos)

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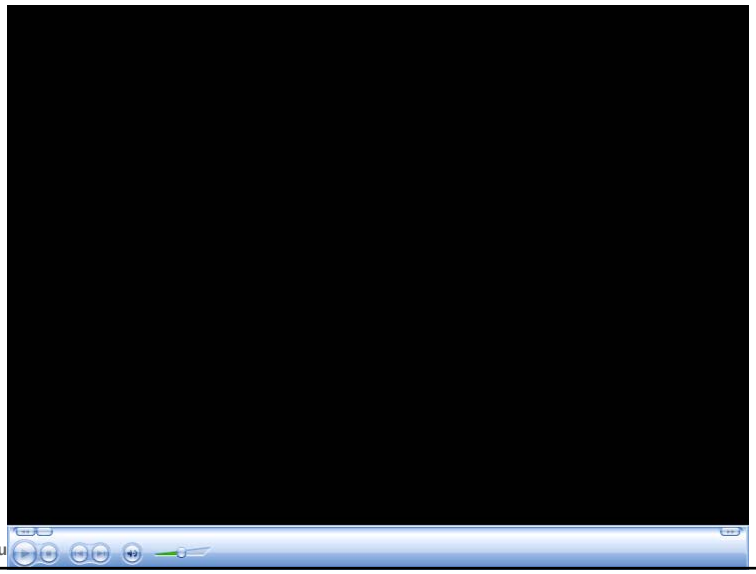
ILScan (TU Innovatives Projekt)

- Stephansdom



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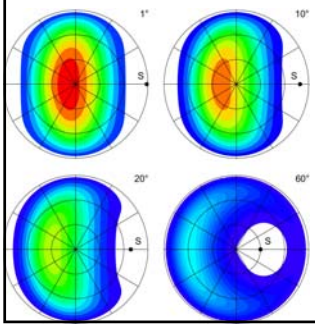
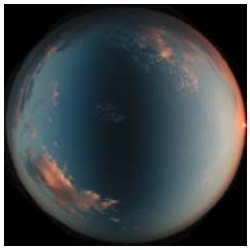
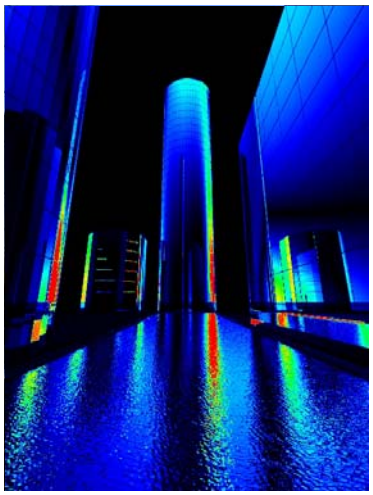
Physically Plausible Skylight Rendering

- Goal: modeling skylight correctly
- applications:
  - architecture
  - outdoor rendering
  - research!







difference image

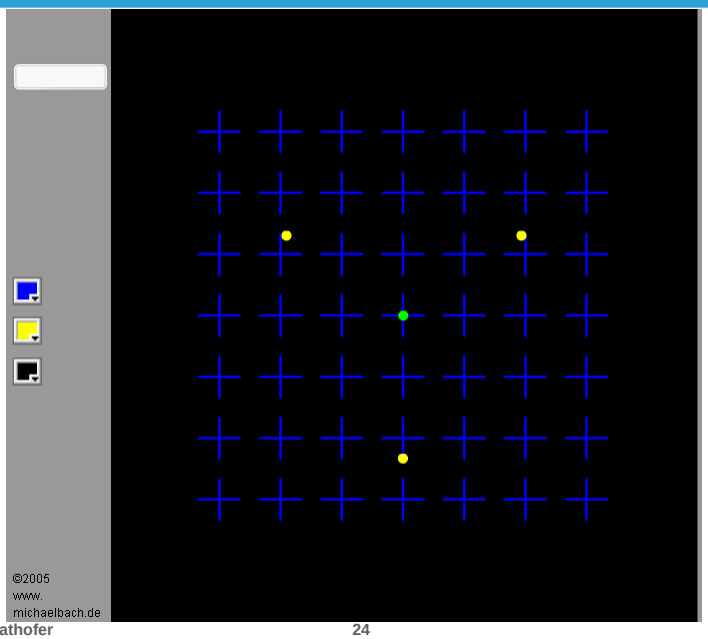
FWF

CrossModal (EU Project)

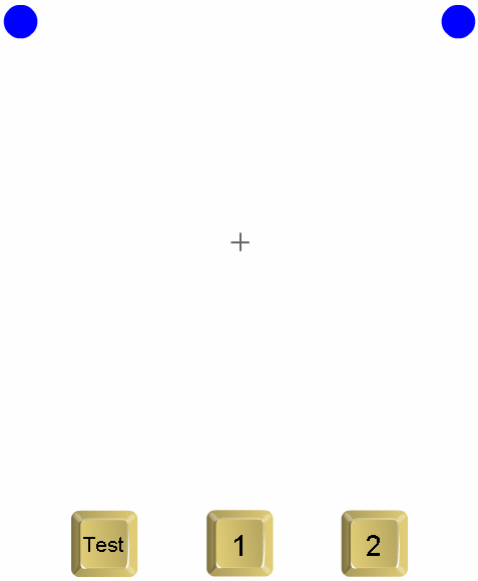
- Goals:
  - study interaction between sound and vision
  - attention guidance
  - more efficient rendering

Information Society Technologies

Motion Induced Blindness

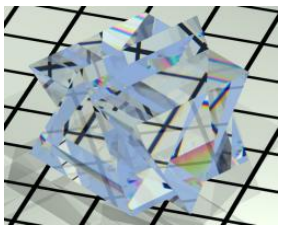


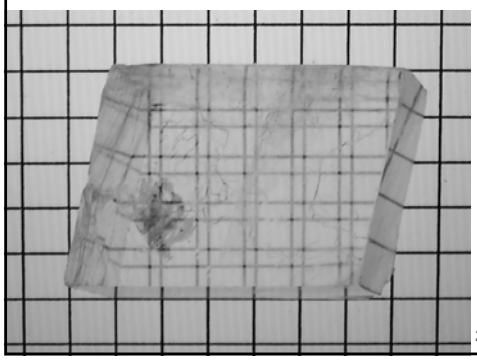
Pinna-Brelstaff Illusion

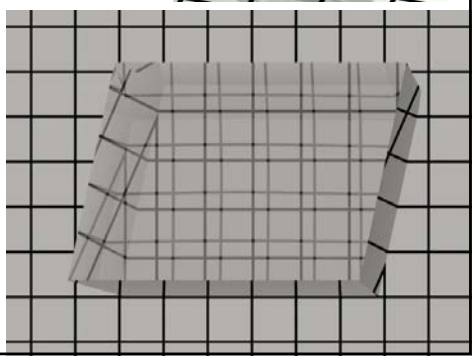


Other Projects: Birefringence in Crystals

- implementation as an extension of standard reflection model
- birefringence depends on
  - refractive indices
  - orientation of the optical axis







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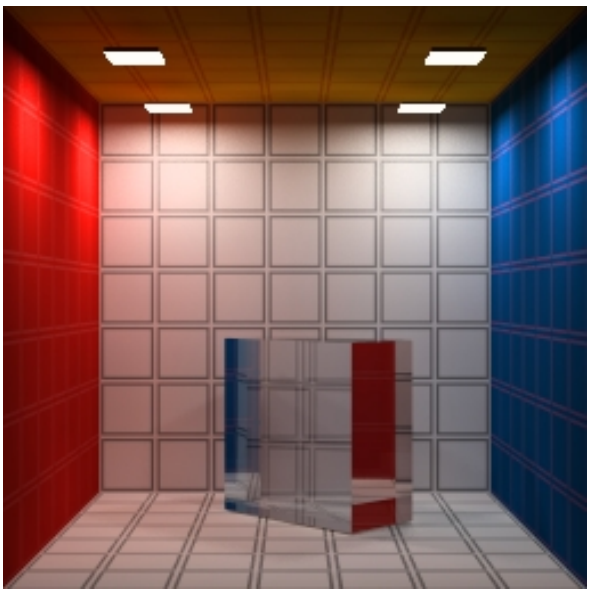
Other Projects: Birefringence in Crystals



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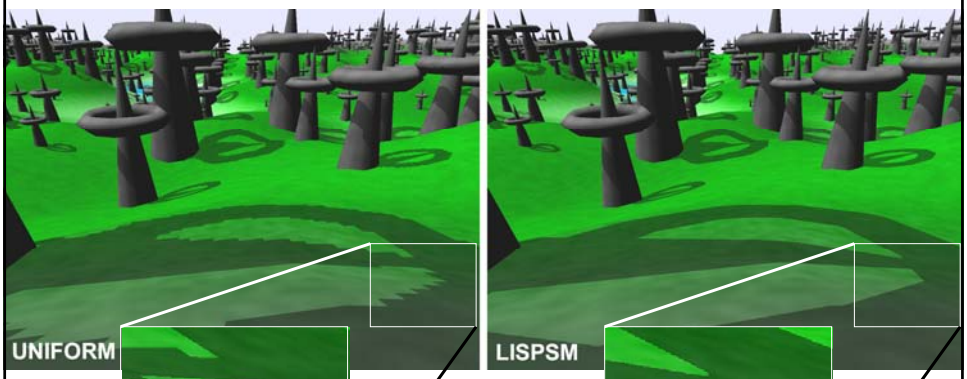
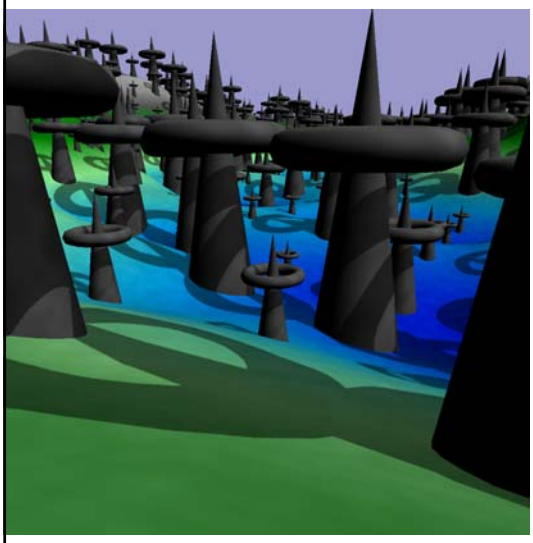
Other Projects: Shadow Rendering

- shadow quality improvements: LiSPSM (Light Space Perspective Shadow Maps)

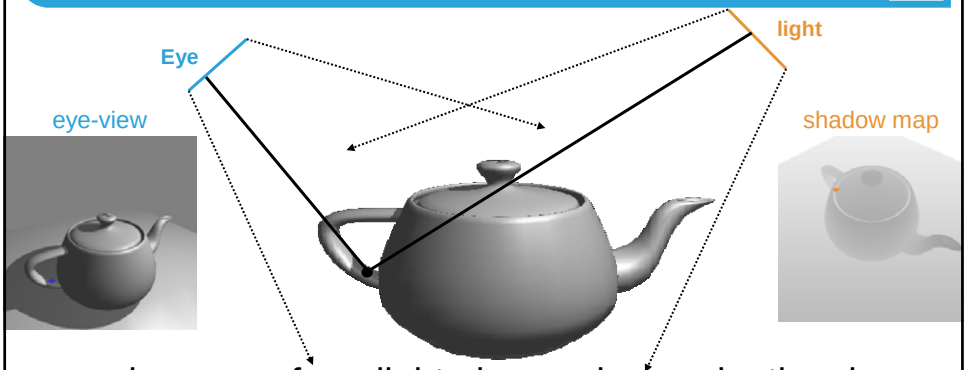


The Goal



- shadow maps for
- **huge** and **dynamic** environments
- more than **100,000** visible triangles
- **automatic** shadow generation
- no artifacts?

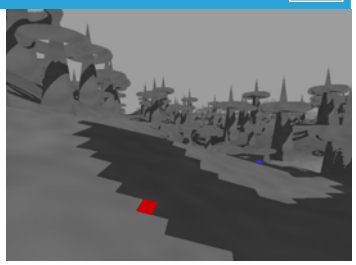
Shadow Map Algorithm: First Pass

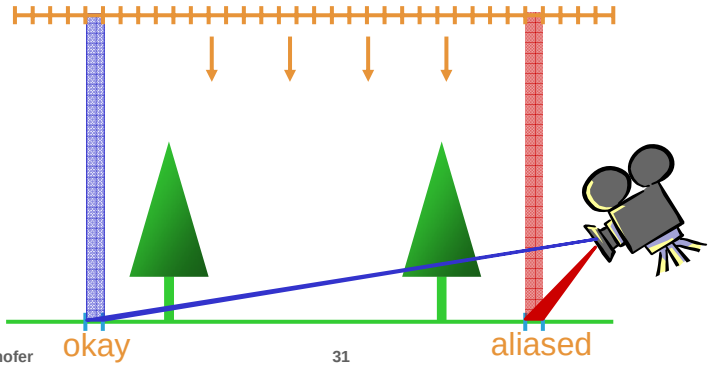


- render scene from light-view and save depth values
- render scene from eye-view
  - transform each fragment to light source space
  - compare z_{eye} with z_{light} value stored in shadow map
  - $z_{eye} > z_{light}$ ➡ fragment is in shadow

Problem: Perspective Aliasing

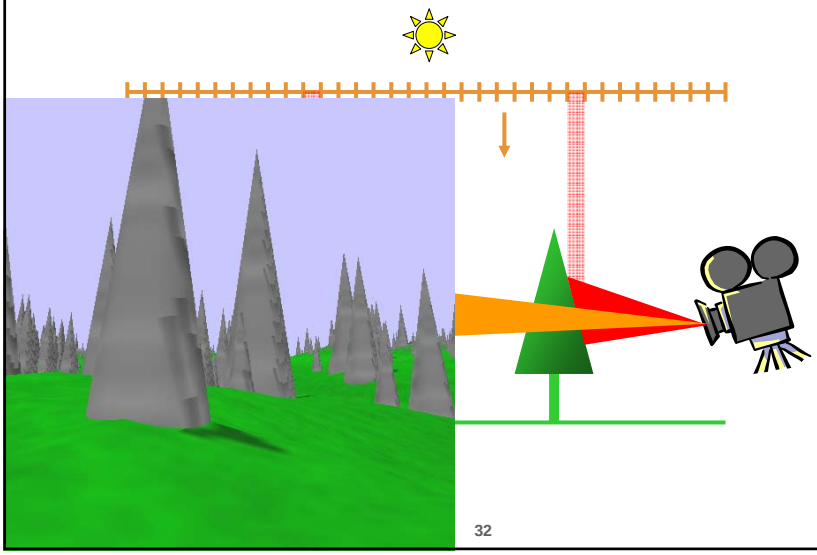
- sufficient resolution far from the observer
- insufficient resolution near the observer



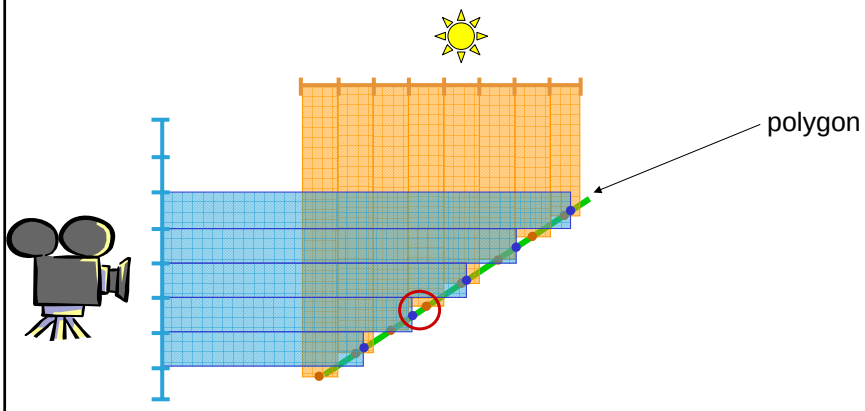


Problem: Projection Aliasing

- receivers ~ perpendicular to shadow plane



Problem: Incorrect Self-Shadowing



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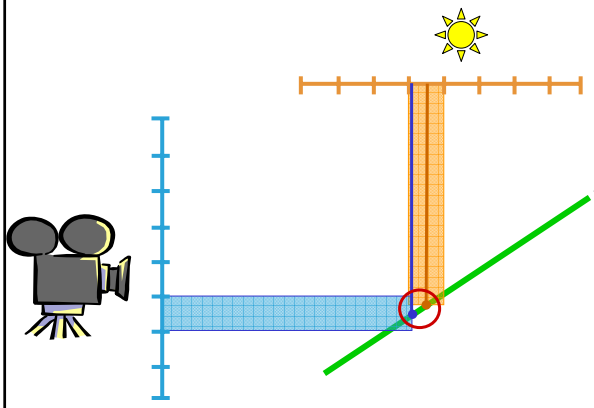
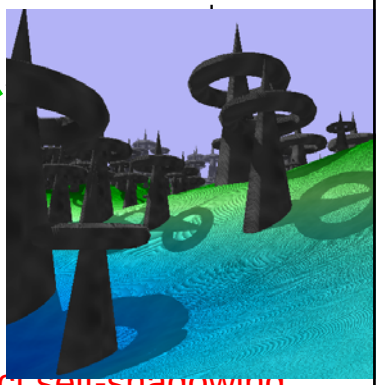
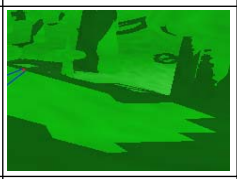
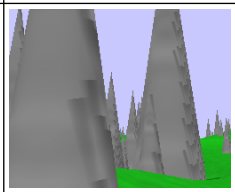
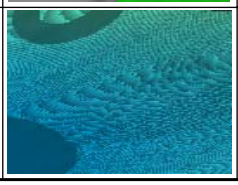




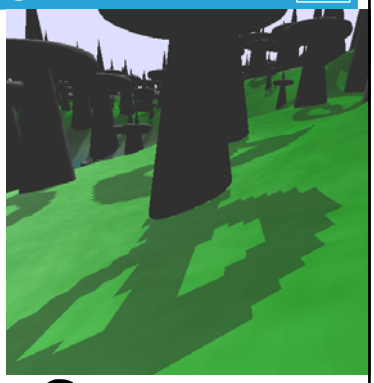
$z_{eye} > z_{light}$ ➡ incorrect self-shadowing

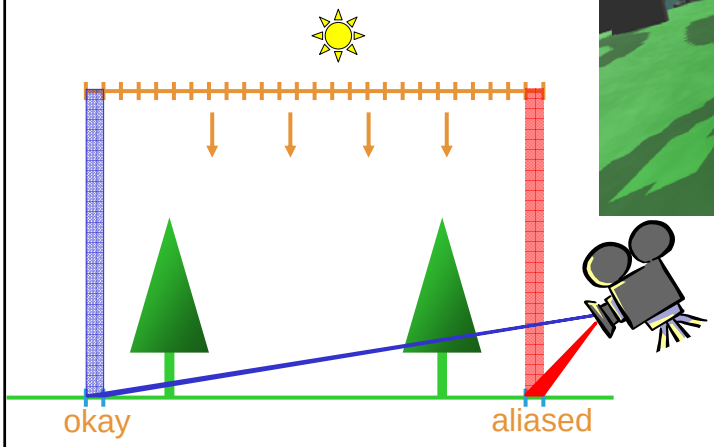
Problems of Shadow Maps

Cause	Sample	Error
perspective aliasing		insufficient resolution near the observer
projection aliasing		insufficient resolution on polygons almost parallel to the light direction
self-(un) shadowing		Moiré-patterns

Solution: Perspective Aliasing

- insufficient resolution near the observer



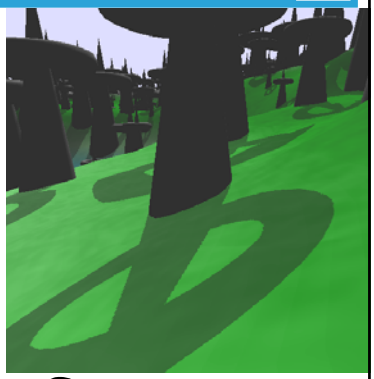


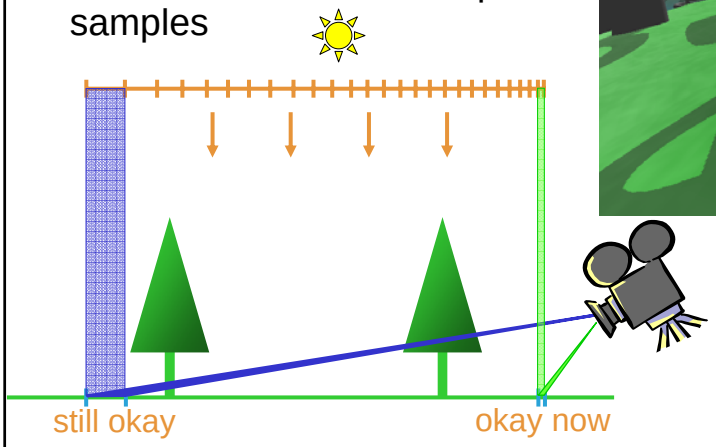
Solution: Perspective Aliasing

- insufficient resolution near the observer
- **redistribute** shadow map samples

Solution: Perspective Aliasing

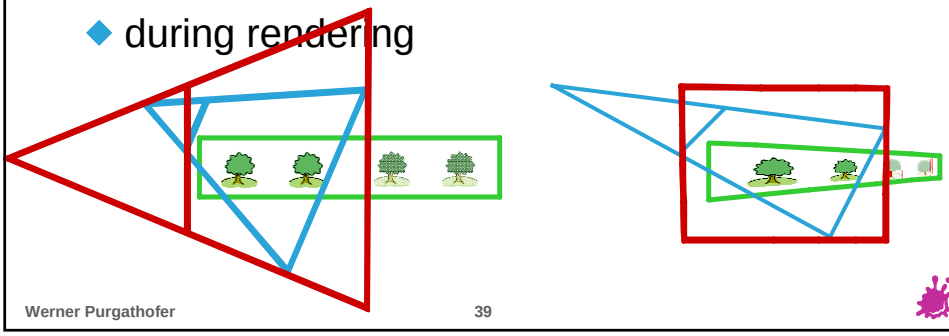
- sufficient resolution near the observer
- **redistribute** shadow map samples





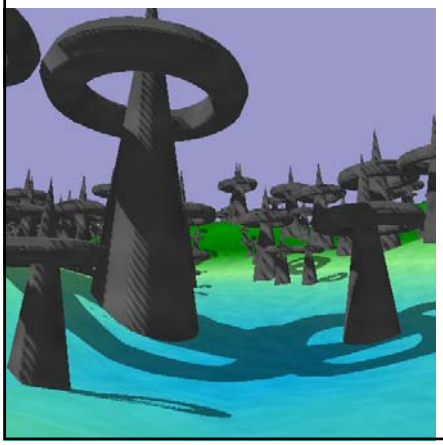
Solution: Perspective Aliasing

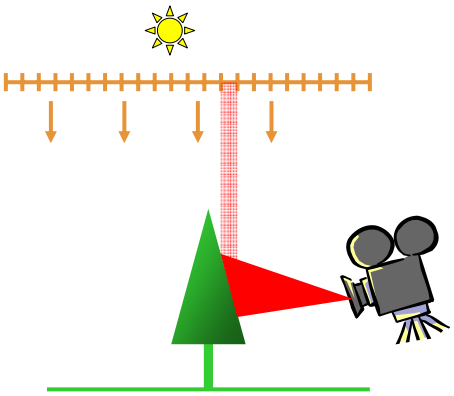
- how do we **redistribute** the shadow map samples?
- using a **perspective transformation**
- just another perspective matrix
  - during shadow map generation
  - during rendering



Solution: Projection Aliasing

- receivers ~ perpendicular to shadow plane
- redistribution doesn‘t work
- **but…**





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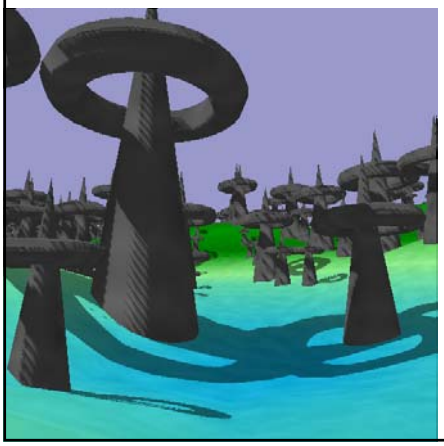
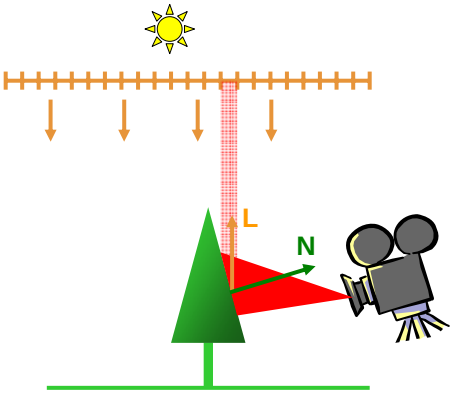
Solution: Projection Aliasing

- diffuse lighting: $I = I_L \, max(\mathbf{L} \cdot \mathbf{N}, 0)$
- ~ perpendicular receivers have small I
- dark ➡ hides artefacts!





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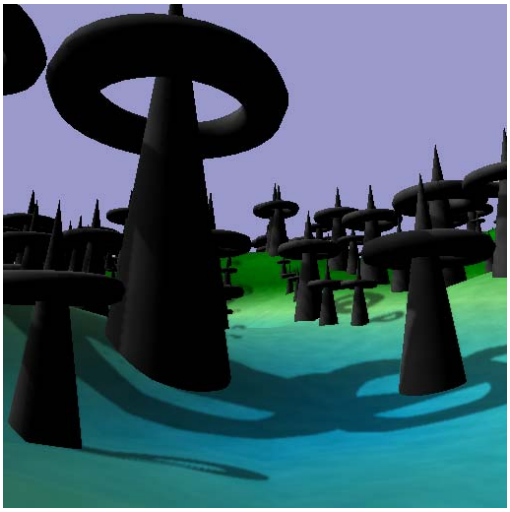
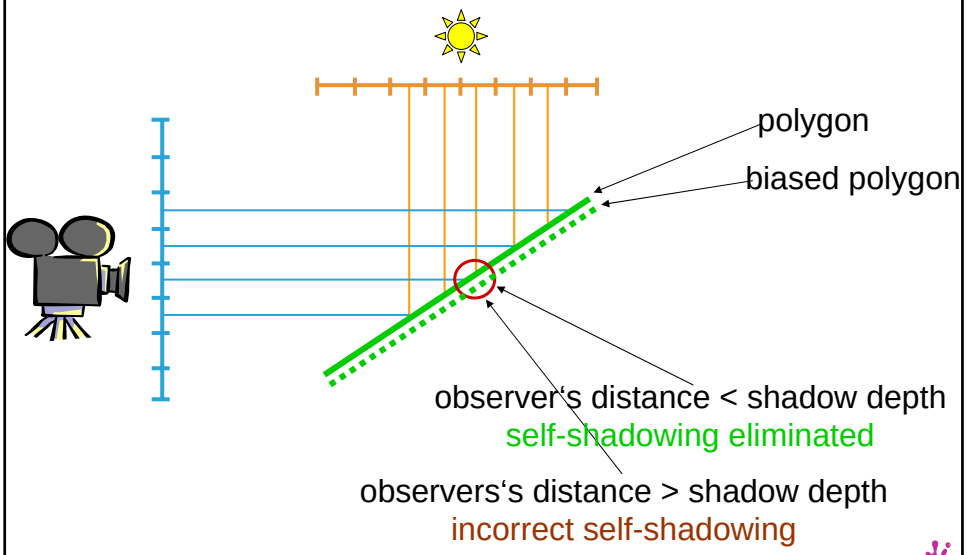
Solution: Projection Aliasing

- screen-space **blur** of shadows
  - hides artefacts
  - shadows become softer

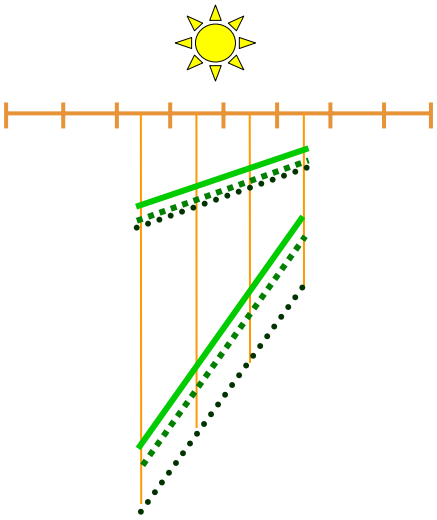


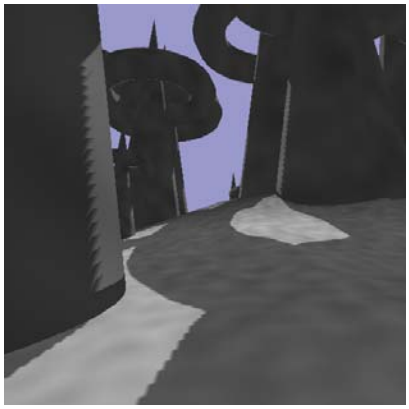
Problem: Self-shadowing



Solution: Self-shadowing

- how do we choose the bias?





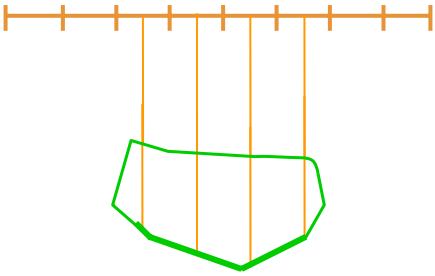
— no biasing

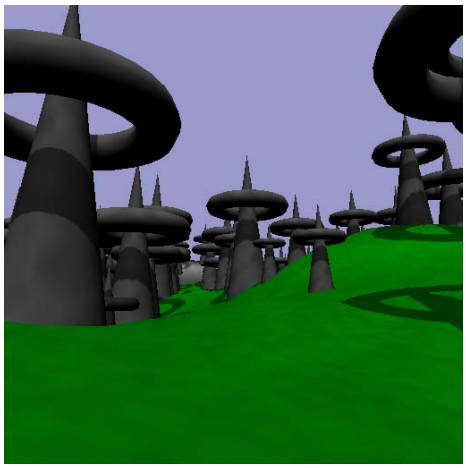
▪▪▪▪ constant biasing

•••• slope-scale biasing

Solution: Self-shadowing

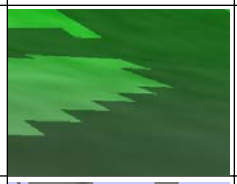
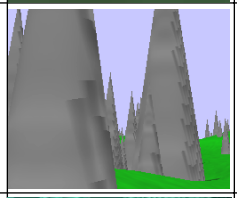
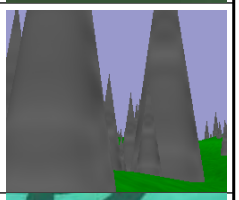
- another possibility to avoid self-shadowing:



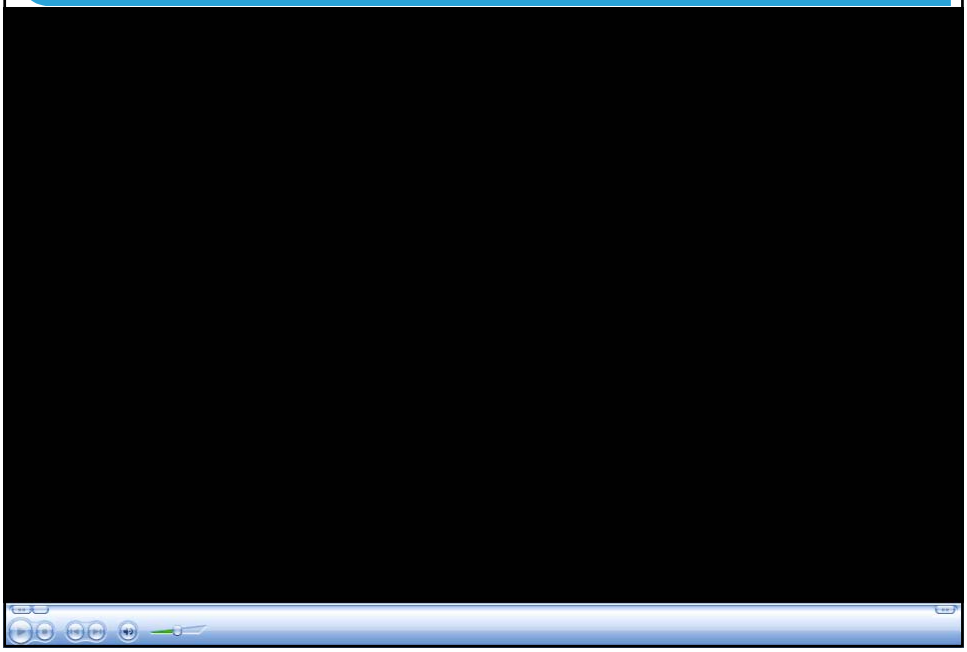


- instead of using the front-side polygons
- use the back-side polygons !

Conclusions

Cause	Sample	Solution	Sample
perspective aliasing		perspective transformation (LispSM)	
projection aliasing		blurring, light-model	
self-(un) shadowing		biasing, back-side rendering	

Putting It All Together

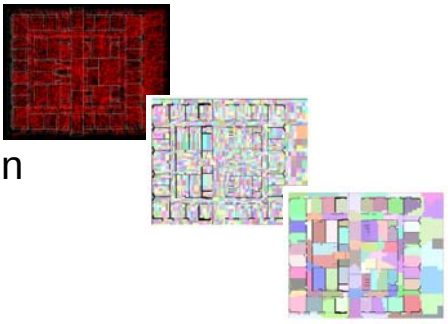


GameTools: View Space Partitioning

- Goal: partition view space into view cells
- what are good view cells (shape, density)?
  - new idea: minimize expected rendering time
  - cost based model

$$c(\mathcal{S}) = \sum_{i \in \mathcal{S}} p(i) r(PVS_i)$$

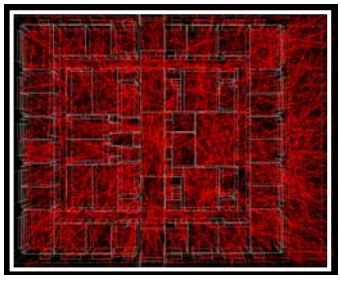
- **3 steps:**
  - visibility sampling
  - view space subdivision
  - view space merging



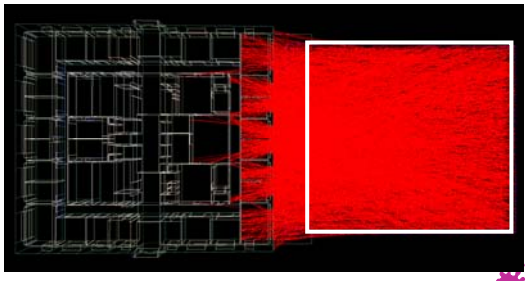
Visibility Sampling

- fast stochastic sampling
- casts rays from potential viewpoints towards scene objects
- relatively small number of samples ~1M

View space = scene bounding box



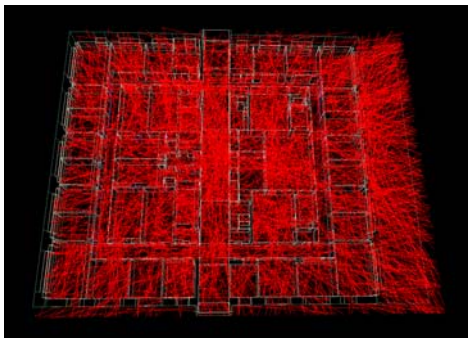
Distant view space



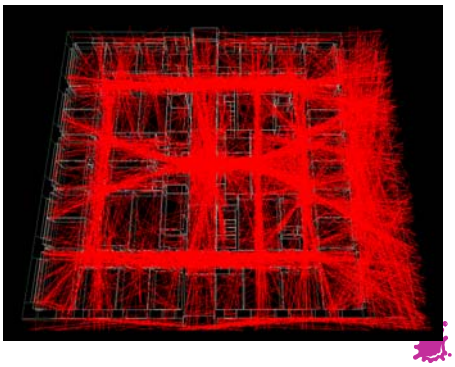
Visibility Sampling - Improvement

- instead of uniformly distributing samples
- user specified probability for viewpoint locations

uniform distribution

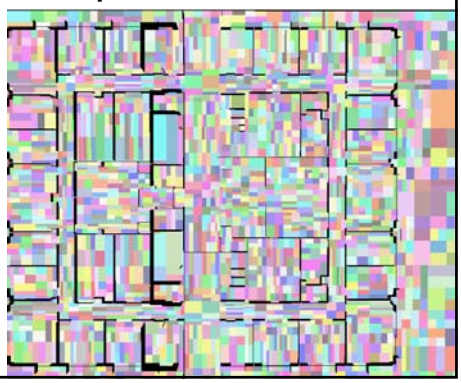


user specified probabilities



View Space Subdivision

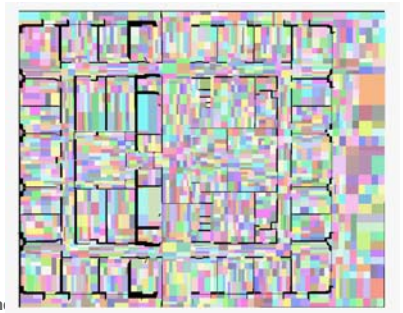
- Binary Space Partitioning (BSP)
- every cell: set of intersecting rays
  - approximate PVS
- expected „global“ render cost
- priority queue for best next split
  - maximal reduction of the render cost
- result: set of elementary cells



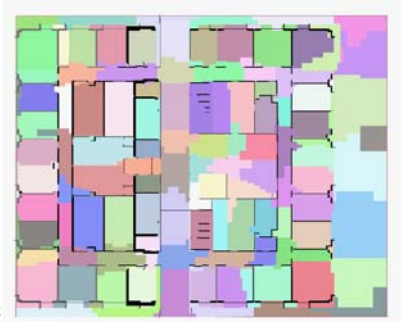
View Space Merging

- bottom-up refinement of the subdivision
- merge view cells while minimizing the render cost increase
- merge history: view cell hierarchy
- allows to extract arbitrary # of cells

5000 view cells

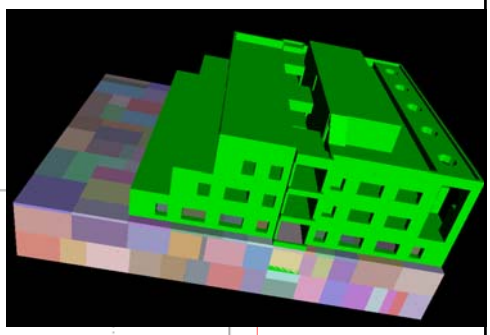


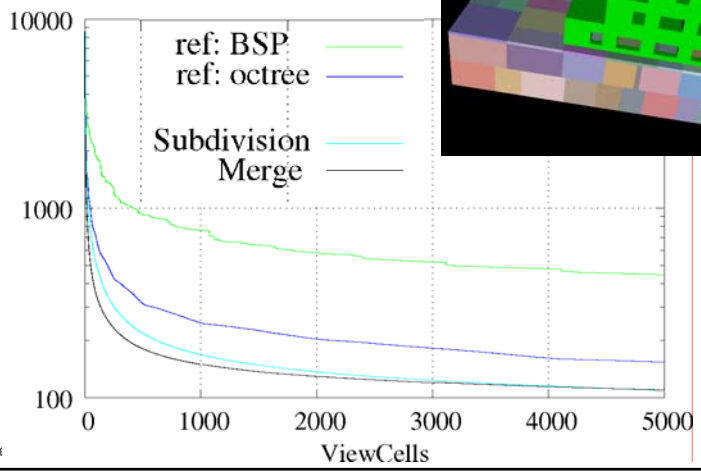
256 view cells



View Space Merging

- average render cost (whole soda building)





The End

- thank you for your attention!
- more at

  www.cg.tuwien.ac.at/research