Proseminar Ausgewählte Themen der Computergraphik

Matthias Teschner

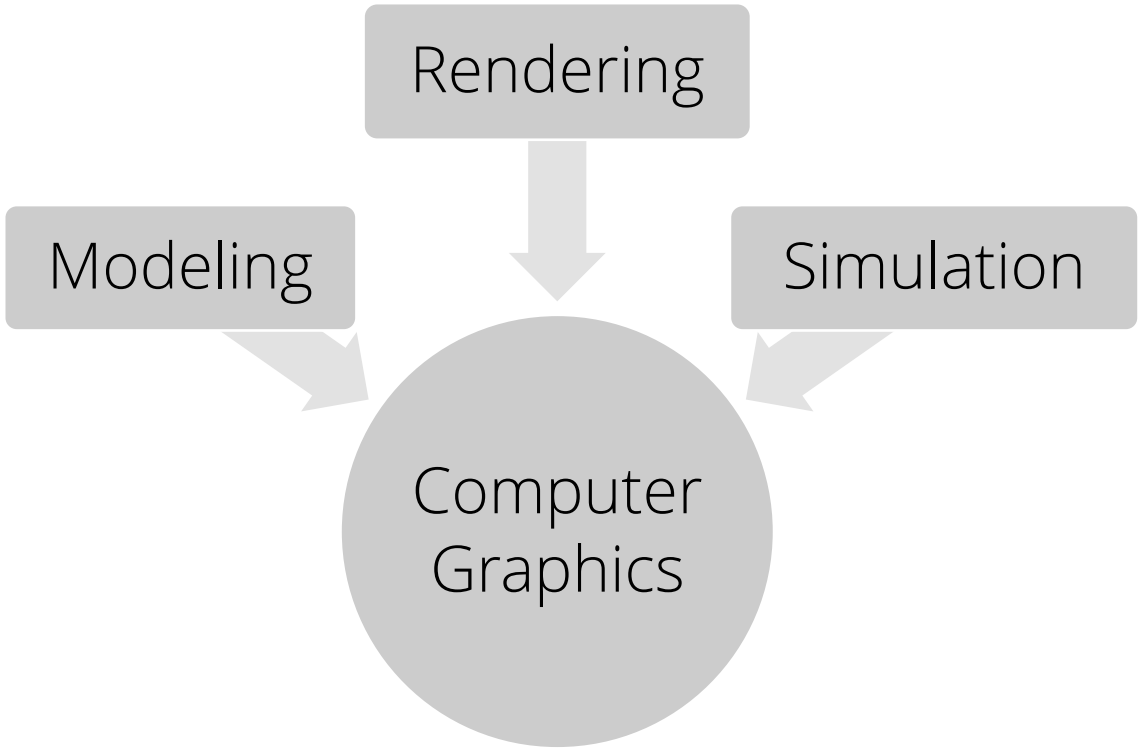
Outline

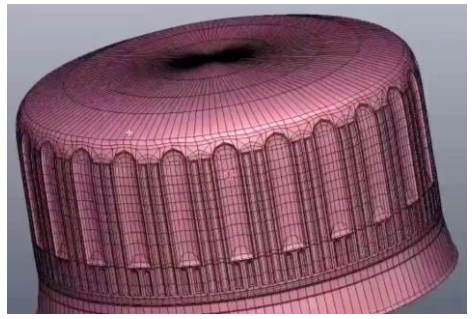
- Introduction
- Organization
- Presentation
- Topics
- Summary

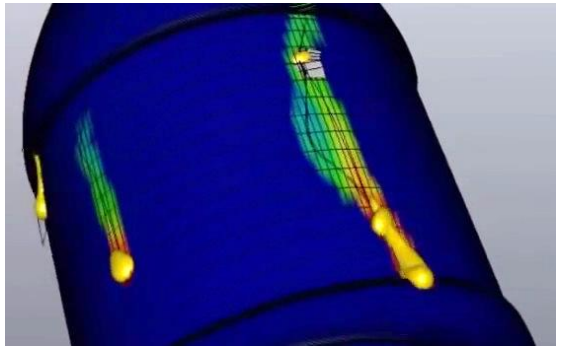
Computer Graphics

- Light
  - Energy or photons transported along lines
  - Generated by light sources, measured / absorbed by sensors, interacts at surfaces and with participating media
- Modeling
  - Geometry, materials, participating media, illumination
- Rendering
  - Computation of light transport
- Simulation
  - Dynamic rigid bodies, deformable objects and fluids

Computer Graphics







CGMeetup: CGI VFX Breakdown HD "Making of Share a Coke Vfx by ARMA" | CGMeetup. [Youtube]

MAKING OF "SHARE A COKE"

Music by: Chocolate Puma & Firebeatz
I Can't Understand (Original Mix)

CGMeetup: CGI VFX Breakdown HD "Making of Share a Coke Vfx by ARMA" | CGMeetup. [Youtube]

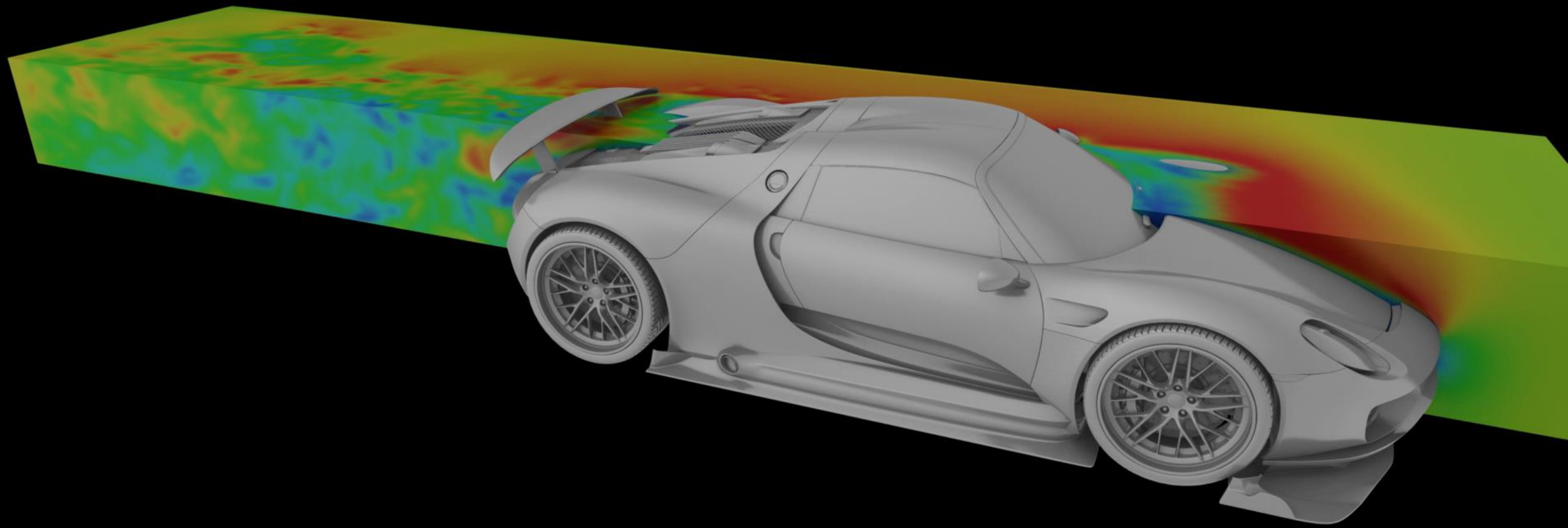
Graphics Courses

- Key course
  - Image processing and computer graphics (modeling, rendering, simulation)
- Specialization courses
  - Advanced computer graphics (global illumination)
  - Simulation in computer graphics (solids and fluids)
- B.Sc. / M.Sc. project, lab course, B.Sc. / M.Sc. thesis
  - Simulation track, rendering track
  - By appointment per email, semester-aligned

Seminars / Projects / Theses in Graphics

Semester	Simulation Track	Rendering Track
Winter	Simulation Course	
Summer	Key Course Lab Course - Simple fluid solver Simulation Seminar	Key Course Lab Course - Simple Ray Tracer Rendering Seminar
Winter	Master Project - PPE fluid solver Rendering Seminar	Rendering Course Master Project - Monte Carlo RT Simulation Seminar
Summer	Master Thesis Research-oriented topic	Master Thesis Research-oriented topic

Gissler et al., ACM Transactions on Graphics, 2019



Band et al., Computer Graphics Forum, 2020.
Cooperation with FIFTY2 Technology GmbH.

J. Idoffson, Chalmers University
Volvo Cars
PreonLab, FIFTY2 Technology

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Requirements

- Oral presentation of a graphics topic
- Written report

Presentations

- Three meetings with three presentations per meeting towards the end of the semester
- Take place at the same time and in the same room as the introduction
  - Announced in the course catalog and on our web page https://cg.informatik.uni-freiburg.de/teaching.htm
- Attendance is mandatory
- No other regular meetings

Report and Submissions

- Written report (approx. 10 pages)
- Submission of presentation slides
  and written report in two separate PDF files
  - YourLastName_report.pdf
  - YourLastName_presentation.pdf
- Per email to Prof. Teschner
- Until the last day of lectures of the semester

Consultations

- Voluntary
- Requested per email
- General discussion of the outline
- Content questions
- Discussion of the fully prepared presentation
- Not later than one week prior the presentation

Information

- https://cg.informatik.uni-freiburg.de/
  - Teaching
    - Ausgewählte Themen der Computergraphik
      - Termine
      - Themen
      - Beispielbericht
      - Beispielpräsentation

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Presentation

- 20 min – 25 min per presentation
- 5 min – 10 min discussion
  - Technical questions
  - Form of the presentation

Preparation

- Know your topic
  - Examine relevant material thoroughly
  - Do not try to circumvent problems
- Prepare slides
  - Allow 1 to 2 minutes per slide
  - Slides should be uniform and not too dense
  - Incorporate illustrations, slide titles should be helpful
- Rehearse your presentation
  - Gather feedback, adapt your presentation accordingly

Presentation

- Introduction
  - Introduce yourself and the title of your presentation
- Overview
  - Give an idea, but not too detailed
- Motivation
  - Illustrate the principle and / or applications
  - Explain the goal of your presentation
  - The audience should be eager to listen your presentation

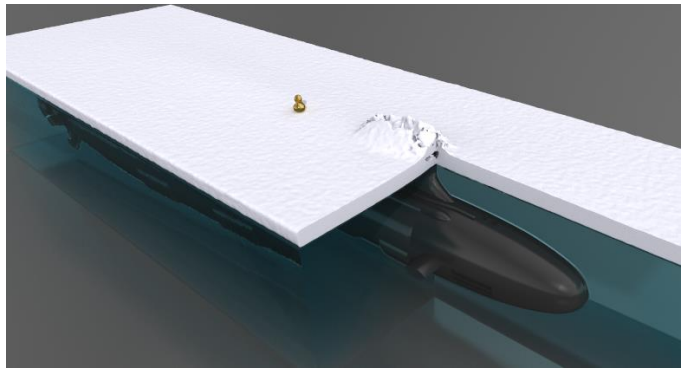
Presentation

- Results
  - Discuss capabilities, properties, benefits, drawbacks
- Main part
  - Should consist of distinguished sections
  - Separate different sections of the presentation explicitly
  - Each section should be introduced and summarized
- Summary
  - Tell the audience what you have told them
  - Ask for questions

References

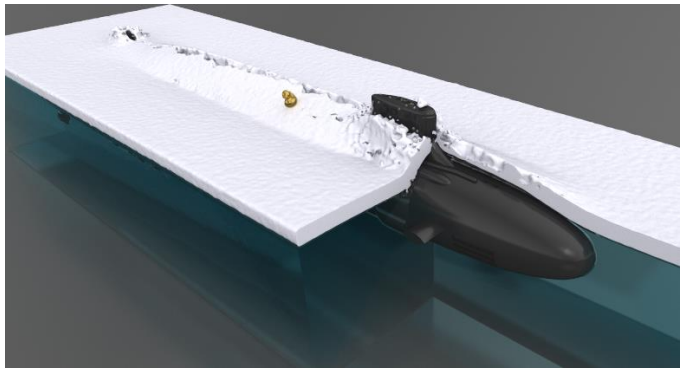
– Third-party material has to be labeled

Good



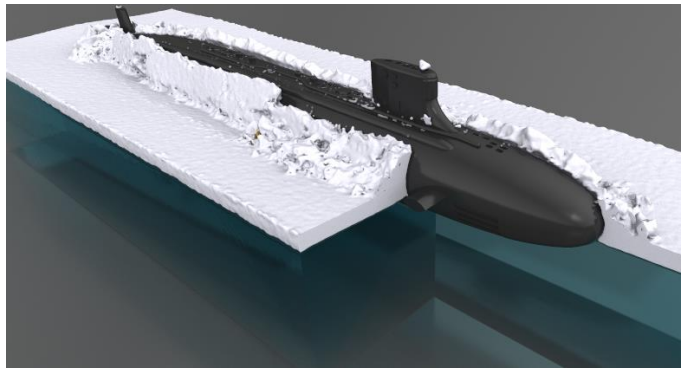
[1]

Good



[Gissler et al. 2020]

Bad



[C. Gissler, A. Henne, S. Band, A. Peer, M. Teschner, An Implicit Compressible SPH Solver for Snow Simulation, ACM Transactions on Graphics (Proc. SIGGRAPH 2020), vol. 39, no. 4, pp. 1-16, August 2020.]

Bibliography

- Examples
  - [1] C. Gissler, A. Henne, S. Band, A. Peer, M. Teschner, An Implicit Compressible SPH Solver for Snow Simulation, ACM Transactions on Graphics (Proc. SIGGRAPH 2020), vol. 39, no. 4, pp. 1-16, August 2020.
  - [Gissler et al. 2020] C. Gissler, A. Henne, S. Band, A. Peer, M. Teschner, "An Implicit Compressible SPH Solver for Snow Simulation", ACM TOG, 2020.
- General form
  - [...] Authors; Title of the material; Name of journal, conference, book, thesis, tutorial, web page, date.
- Wrong form
  - [1] https://cg.informatik.uni-freiburg.de/publications/2020_SIGGRAPH_snow_v6.pdf

Presentation

- Check the presentation environment prior to the presentation
- Do not occlude the projection
- Avoid idiosyncrasies
- Stay in time

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      - Themen

Topics - Example

Homogeneous coordinates

Die homogene Notation ist eine in der Graphik häufig verwendete Repräsentation von Positionen und Richtungen, die eine einheitliche Realisierung vielfältiger Transformationen von Positionen und Richtungen durch ein einfaches Matrix-Vektor-Produkt ermöglicht.

Quellen:

- https://cg.informatik.uni-freiburg.de/course_notes/graphics_03_homogeneousNotation.pdf
- https://de.wikipedia.org/wiki/Homogene_Koordinaten

Topics

- Rendering

  Rendering pipeline, Bresenham algorithm, Ray tracing, Phong illumination model, William shadow mapping

- Modeling

  Marching Cubes, Mesh simplification

- Animation

  Particle systems

- Tools

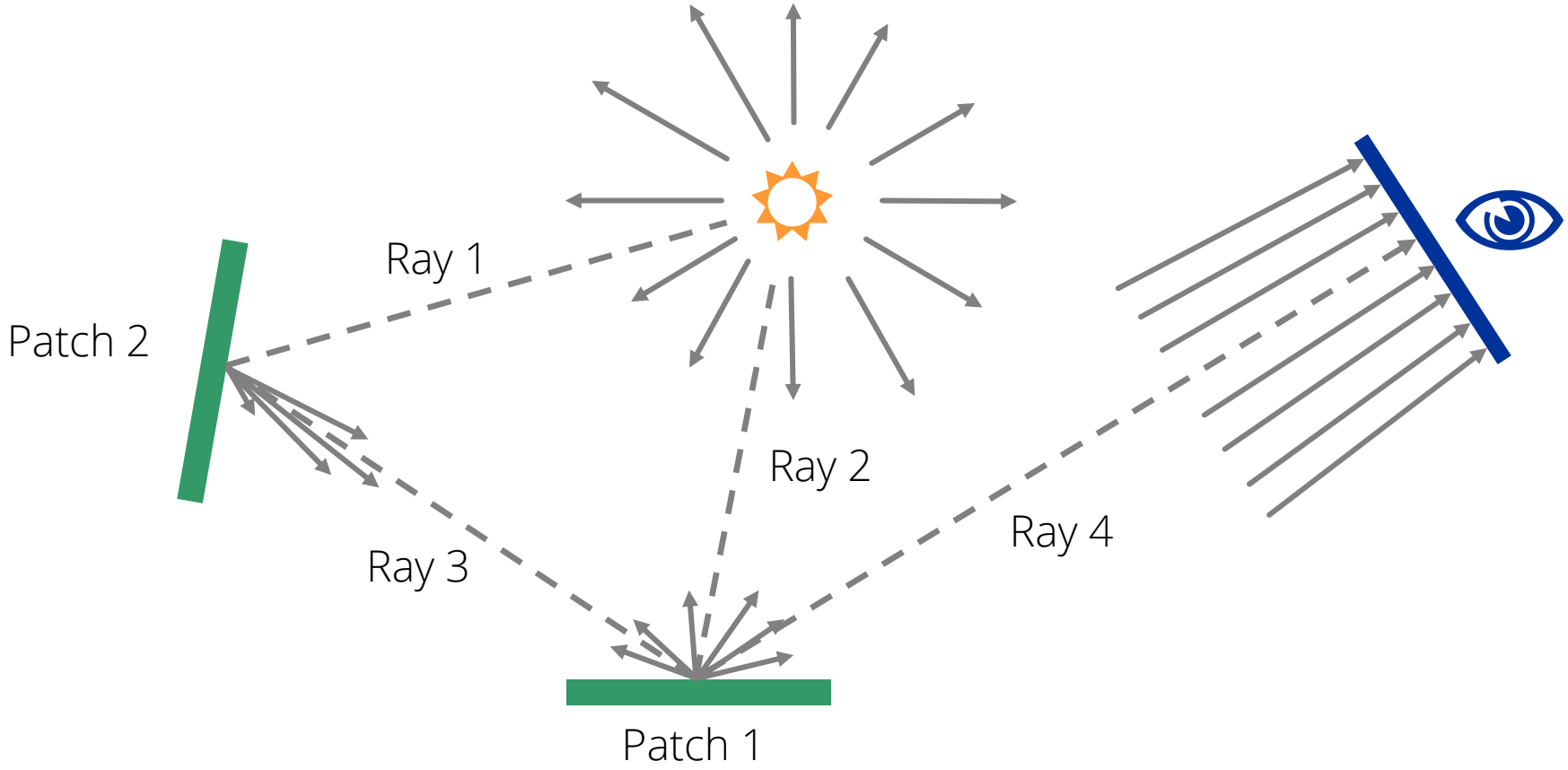
  Homogeneous coordinates

Modeling and Rendering

© Will Gibbons Design

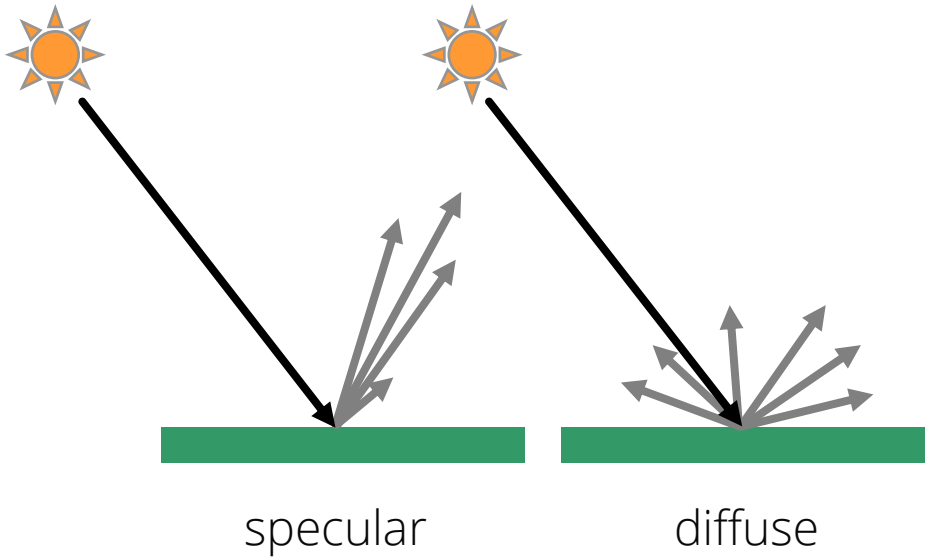
Ray Tracing

– Computation of light transport along rays



Illumination Model

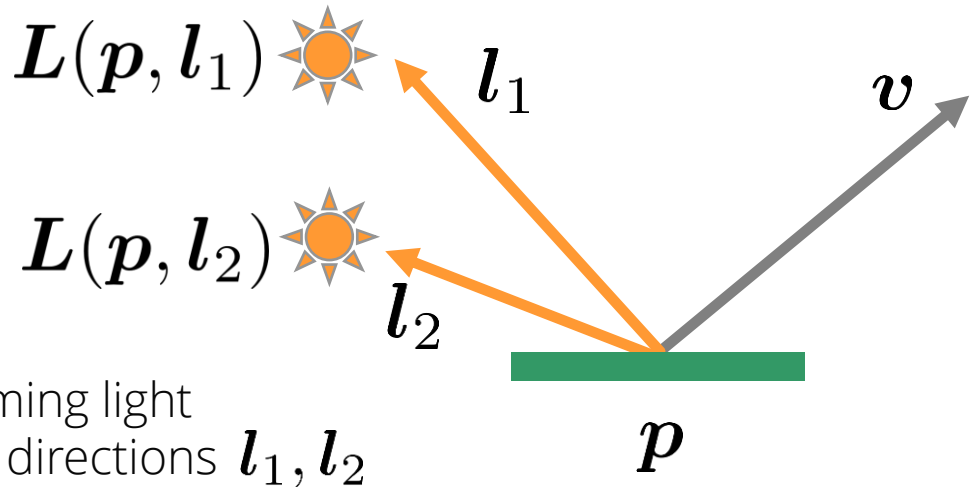
– Computes reflected light at surfaces considering illumination and material



Incoming light is scattered and absorbed at surfaces dependent on the material

Phong Illumination Model

– Computes reflected light at surfaces considering illumination and material



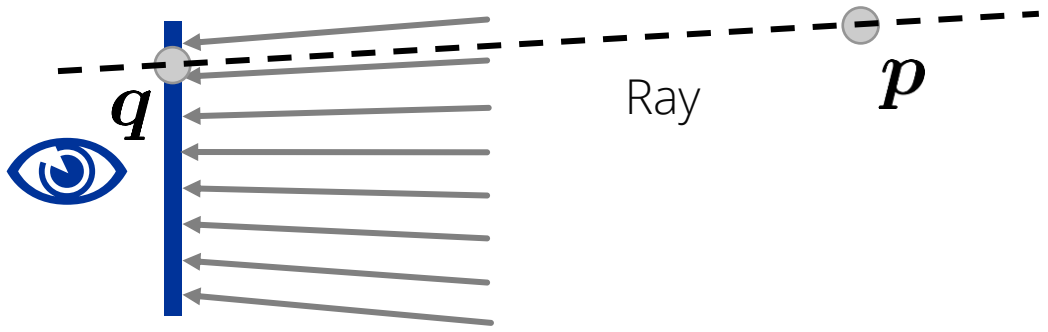
Incoming light from directions l_1, l_2 from two light sources

$$L(p, v) = \sum_i f_{\text{Phong}}\left(L(p, l_i)\right)$$

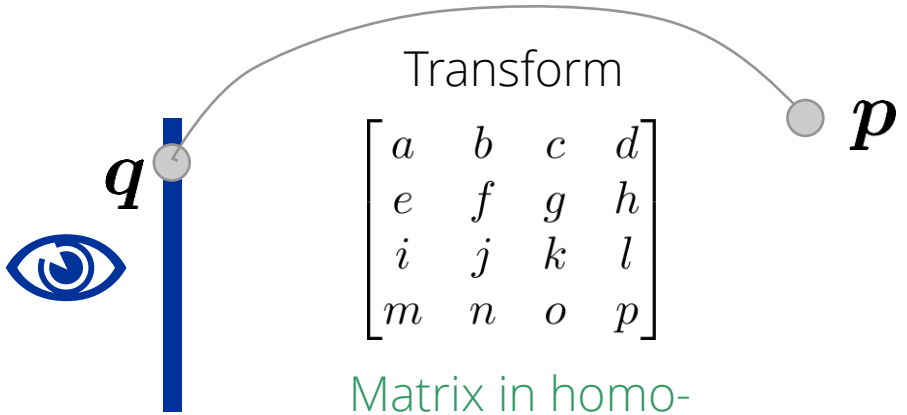
f_{Phong} computes reflected light into direction v towards the sensor considering illumination from directions l_i.

Ray Tracing vs. Rasterization

– Solve the visibility problem

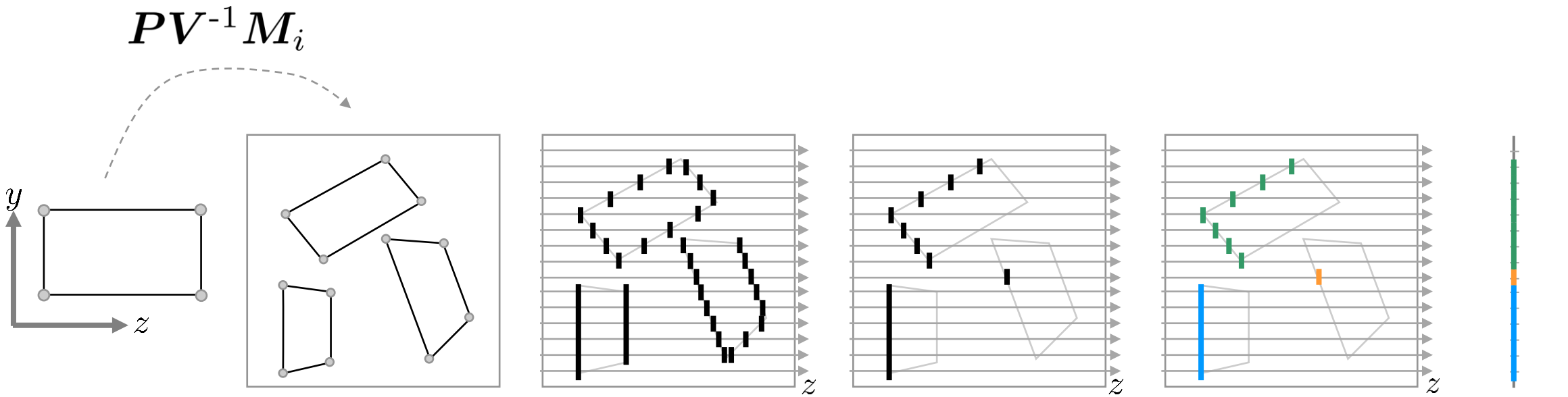


Ray Tracers compute ray-scene intersections to estimate *q* from *p*.



Rasterizers apply transformations to *p* in order to estimate *q*. *p* is projected onto the sensor plane.

Rendering Pipeline



Object in local space

Scene in the canonical view volume

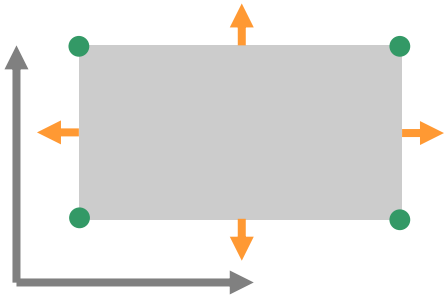
Rasterization

Visibility

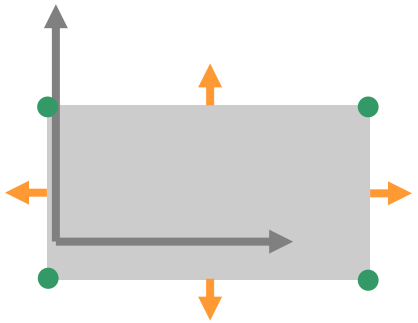
Shading (e.g. Phong)

Image

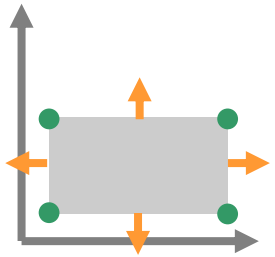
Transformations



Four faces / primitives / polygons, four points / vertices, four normals

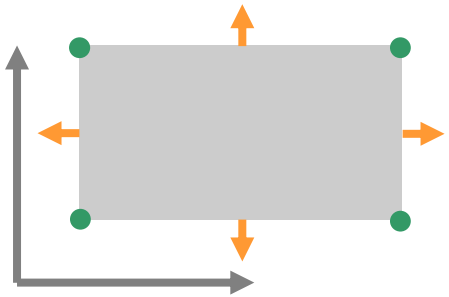


Translation

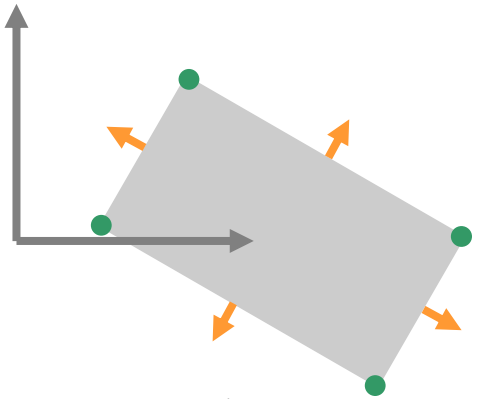


Scale

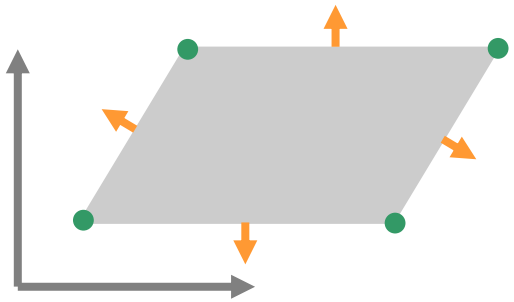
Transformations change vertex positions and surface normals.



Identity transform



Rotation



Shear

Homogeneous Notation

- All transformations of positions and directions are uniformly realized as a matrix-vector product
- Translation of a point $\mathbf{p} = (p_x, p_y, p_z)^\mathsf{T}$ and a vector $\mathbf{v} = (v_x, v_y, v_z)^\mathsf{T}$ by a vector $\mathbf{t} = (t_x, t_y, t_z)^\mathsf{T}$

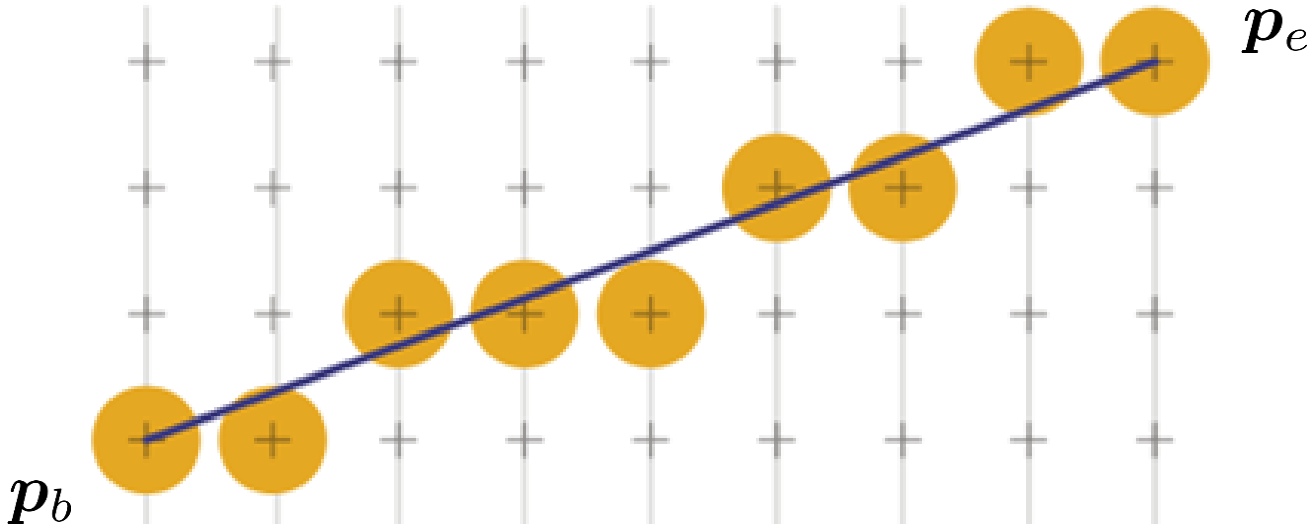
$$\begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} p_x \\ p_y \\ p_z \\ 1 \end{bmatrix} = \begin{bmatrix} p_x + t_x \\ p_y + t_y \\ p_z + t_z \\ 1 \end{bmatrix} \qquad \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} v_x \\ v_y \\ v_z \\ 0 \end{bmatrix} = \begin{bmatrix} v_x \\ v_y \\ v_z \\ 0 \end{bmatrix}$$

Translation of a point in homogeneous notation

Translation of a vector in homogeneous notation

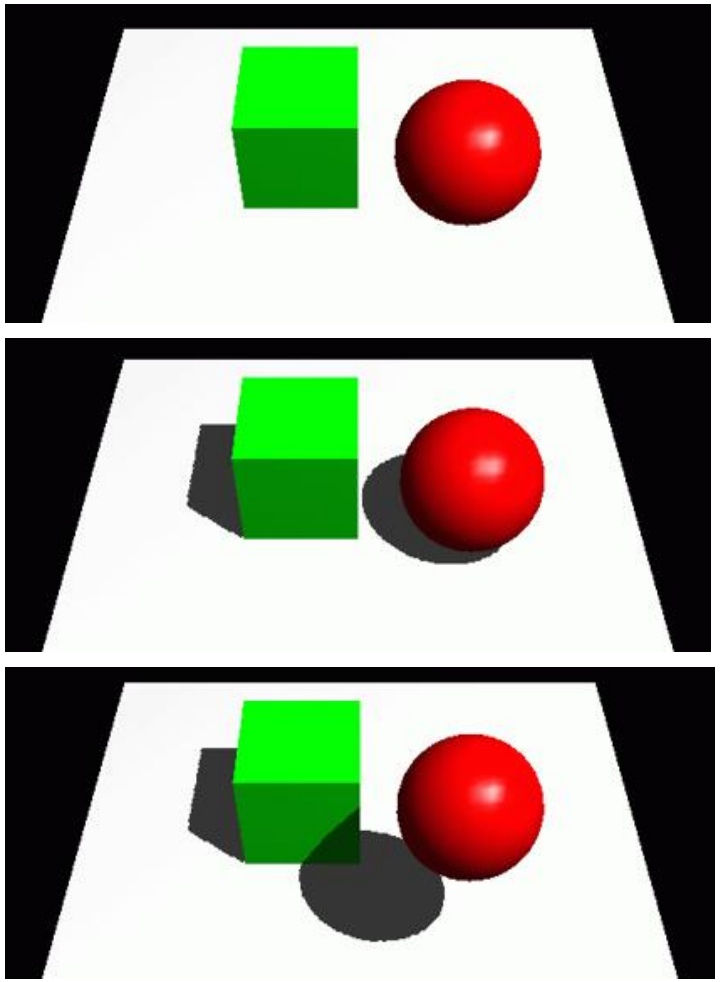
Bresenham Algorithm

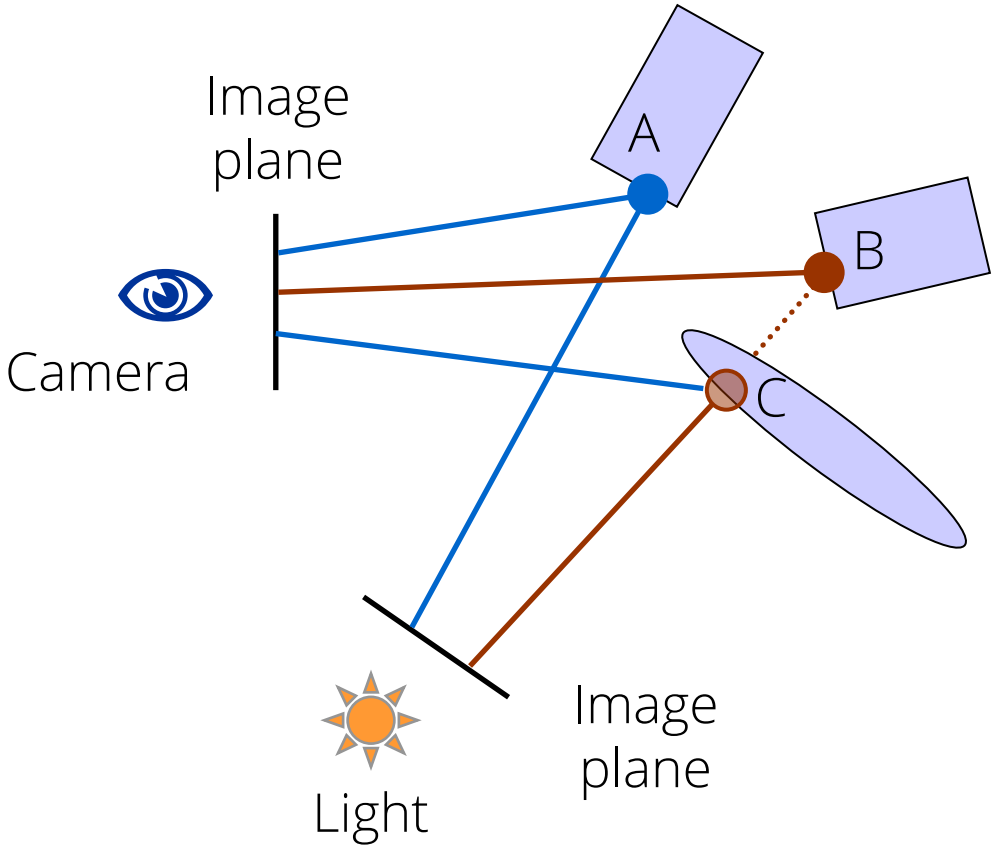
– Estimation of pixel positions that approximately represent a line from $\boldsymbol{p}_b = (x_b, y_b)$ to $\boldsymbol{p}_e = (x_e, y_e)$



Wikipedia: Rasterung von Linien

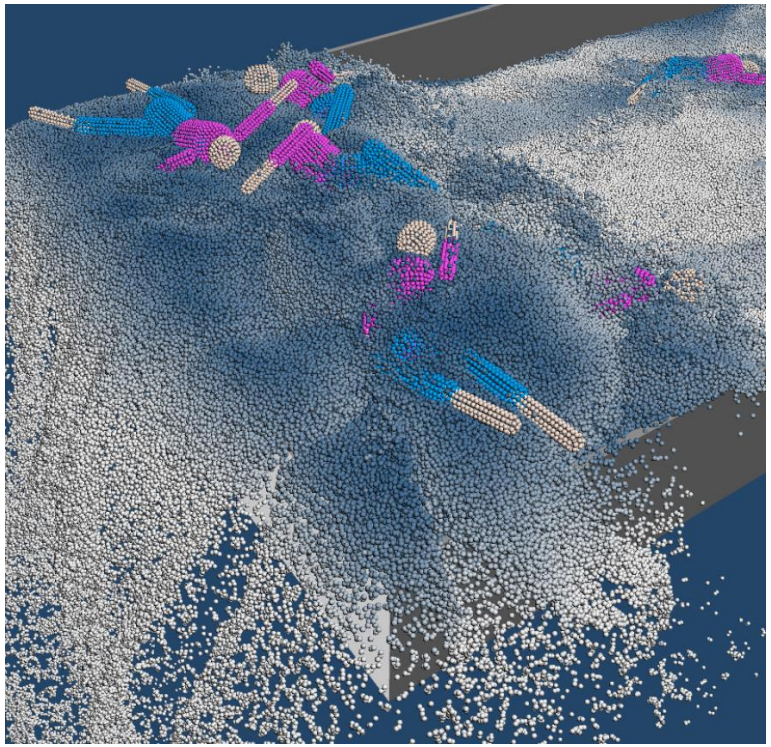
Shadow Mapping

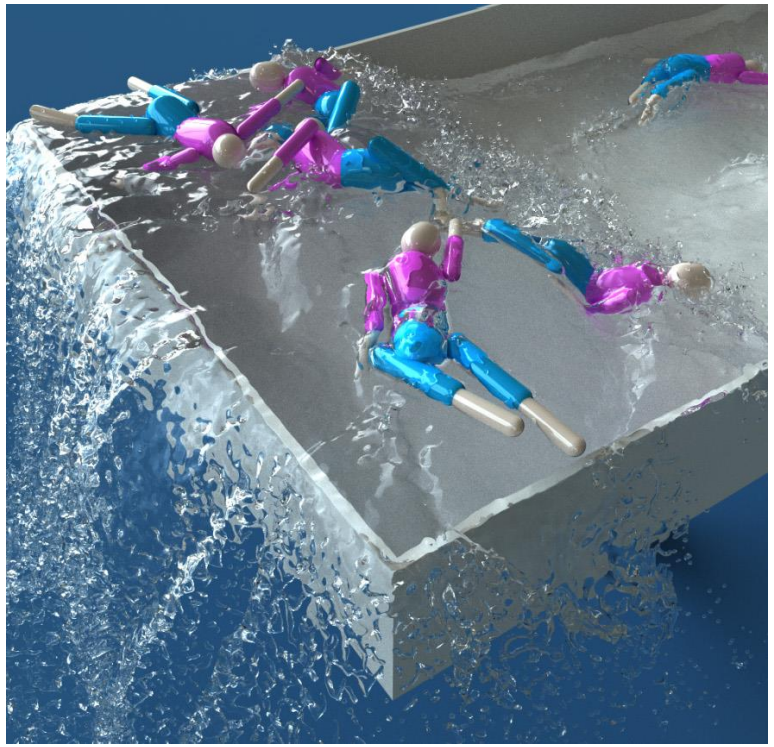




Marching Cubes

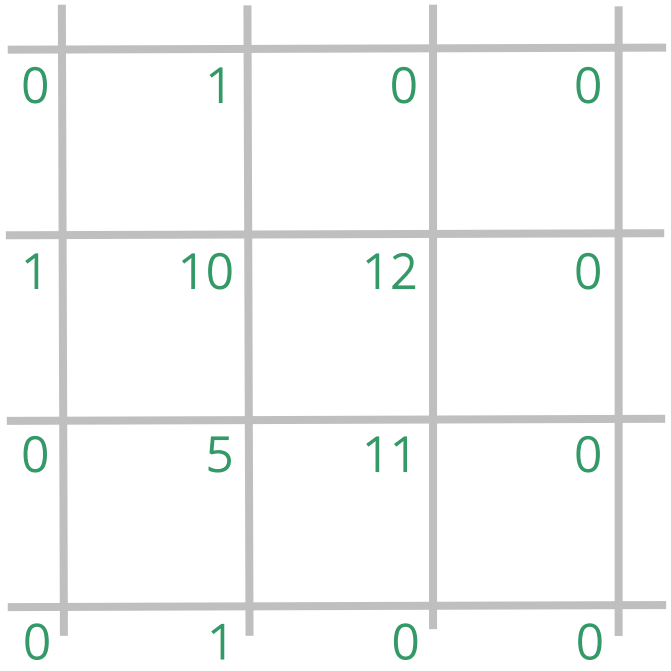
– Reconstruction and rendering of a triangulated iso-surface



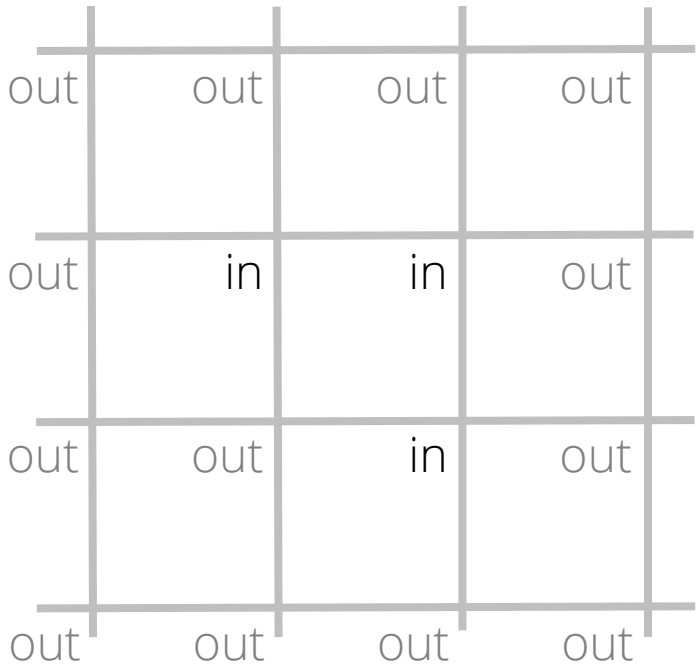


Akinci et al.: Versatile Rigid-Fluid Coupling for Incompressible SPH

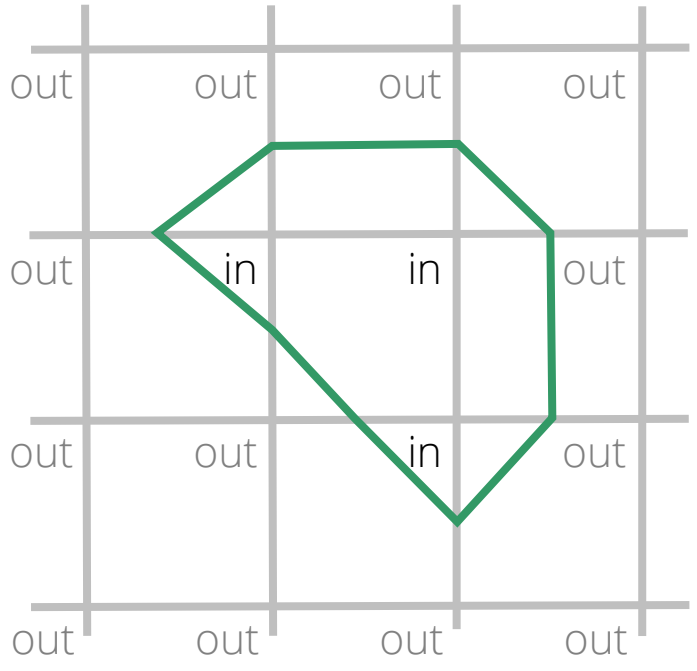
Marching Cubes



Input: Scalar field



Classification with respect to an iso-value, e.g. 8



Output: Triangulated iso-surface

Mesh Simplification

577 k triangles

Botsch et al.: Polygon Mesh Processing

10 %

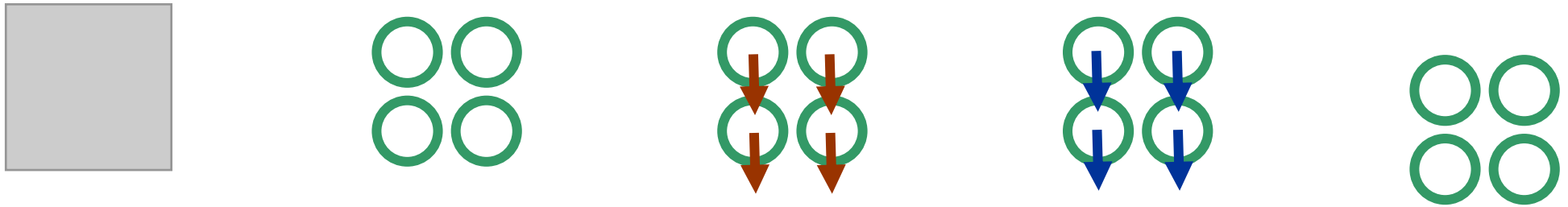
1 %

0.1 %

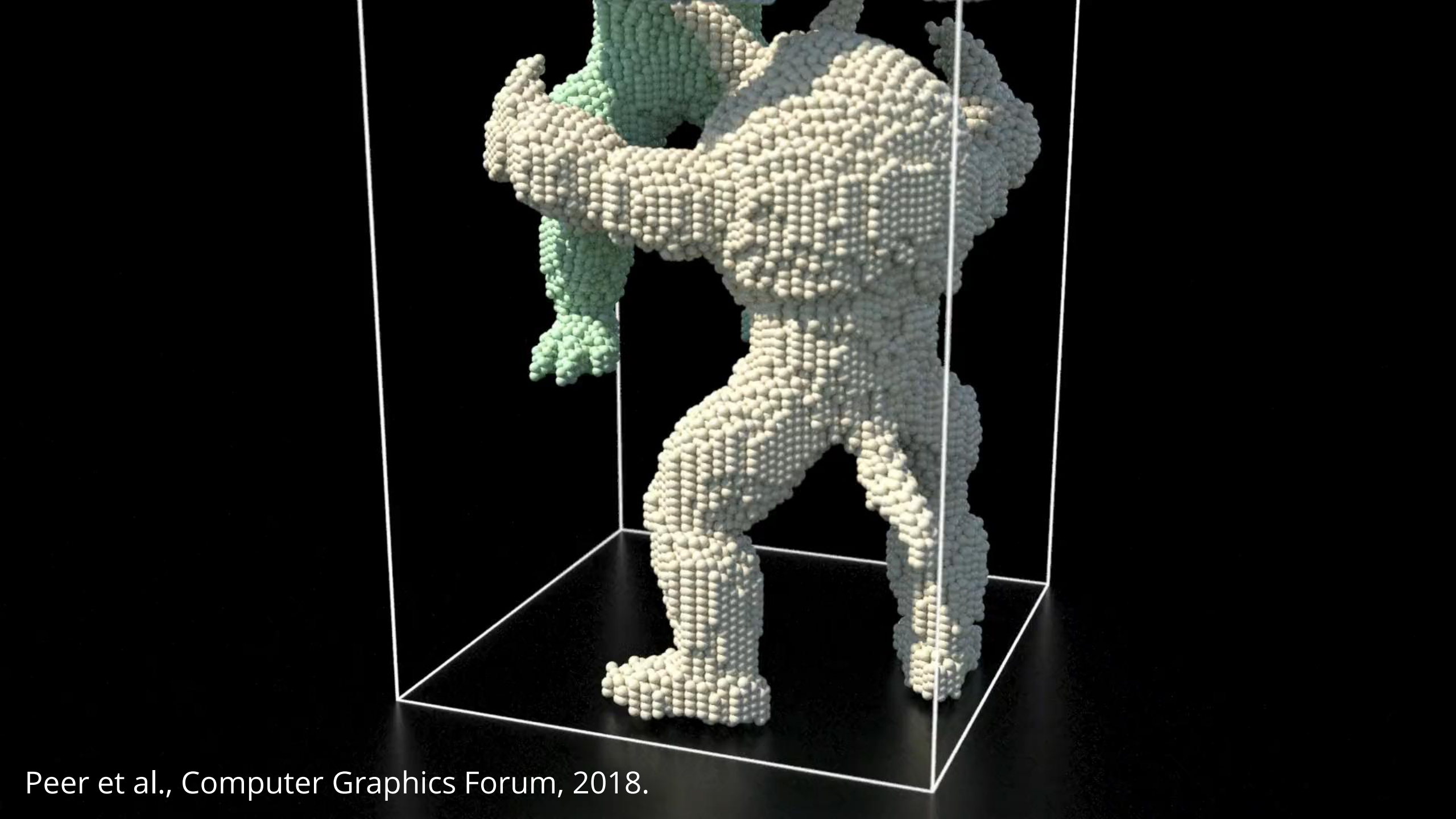
Particle Systems

- Particle representation
- Force computation
- Particle motion

$$\frac{\boldsymbol{F}}{m} = \frac{\mathrm{d}\boldsymbol{v}}{\mathrm{d}t} = \frac{\mathrm{d}^2\boldsymbol{x}}{\mathrm{d}t^2}$$



Object | Particles | Acceleration | Velocity change | Position change



Peer et al., Computer Graphics Forum, 2018.

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Summary

- Oral presentation of 20 – 25 min
- Written report of 10 pages
- Two voluntary consultations
- Topics overview and presentation dates
  - https://cg.informatik.uni-freiburg.de/teaching.htm
    - Ausgewählte Themen der Computergraphik
    - Termine / Themen

Registration

- Check for available topics and dates
  - https://cg.informatik.uni-freiburg.de/teaching.htm
    - Ausgewählte Themen der Computergraphik
      - Termine / Themen
- Send an email to Prof. Teschner with your registration request stating
  name, topic, date, matriculation number
- Do not forget to check your registration in the campus management system