Illustrative Visualization of Technical 3D Models

Ladislav Čmolík

Czech Technical University in Prague

Computer Graphics Group

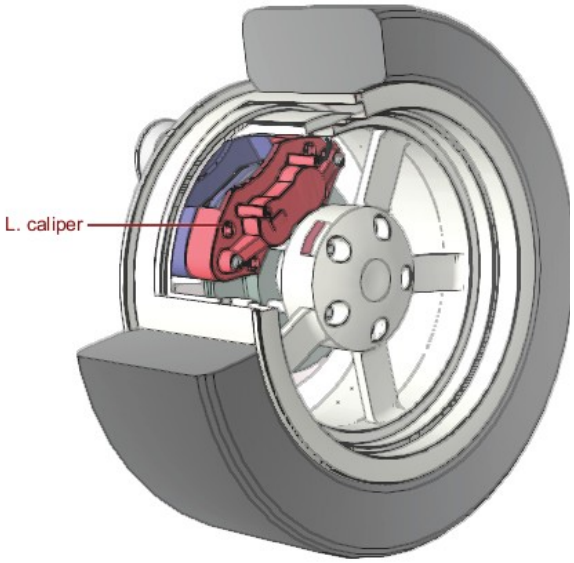
Motivation and Goals

- Technical 3D model – large number of 3D meshes
  - Visible boundary
  - Inner structure
- Exploration of technical 3D models is challenging cognitive activity

- Enable interactive exploration of technical 3D models
  - Communication of shape, spatial and topological relations

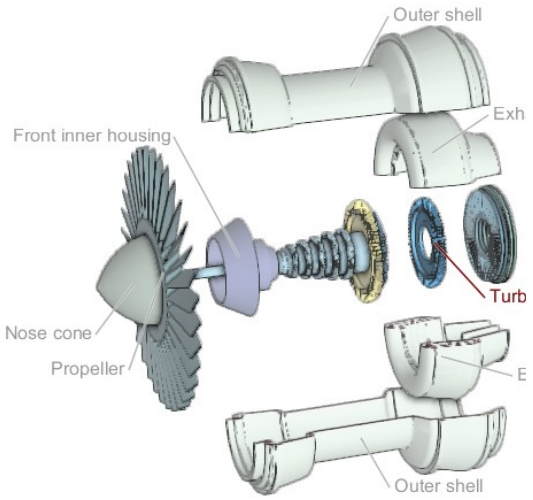
Illustrative Techniques

Cut-away views



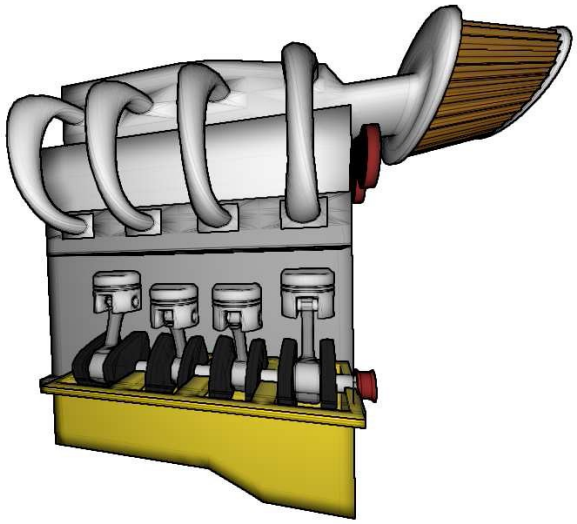
- Occluding geometry is cut away

Exploded views



- Position of parts is distorted in reverse of the assembly process

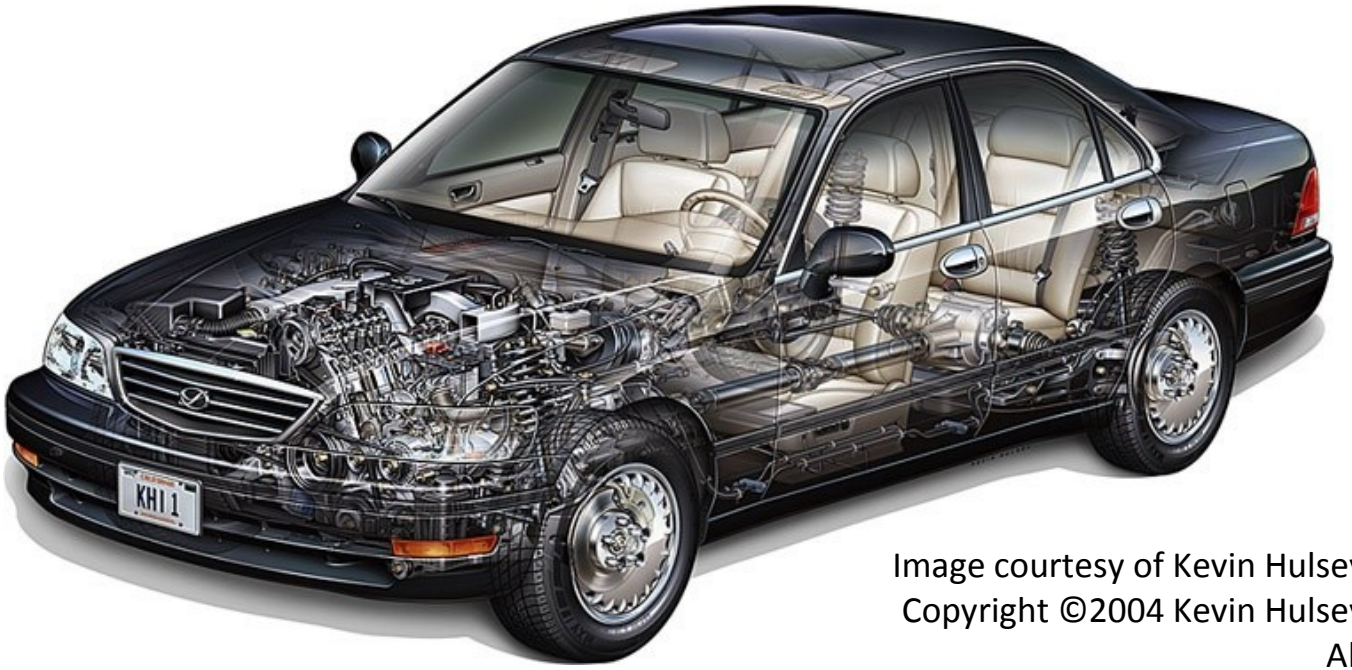
Ghosted views



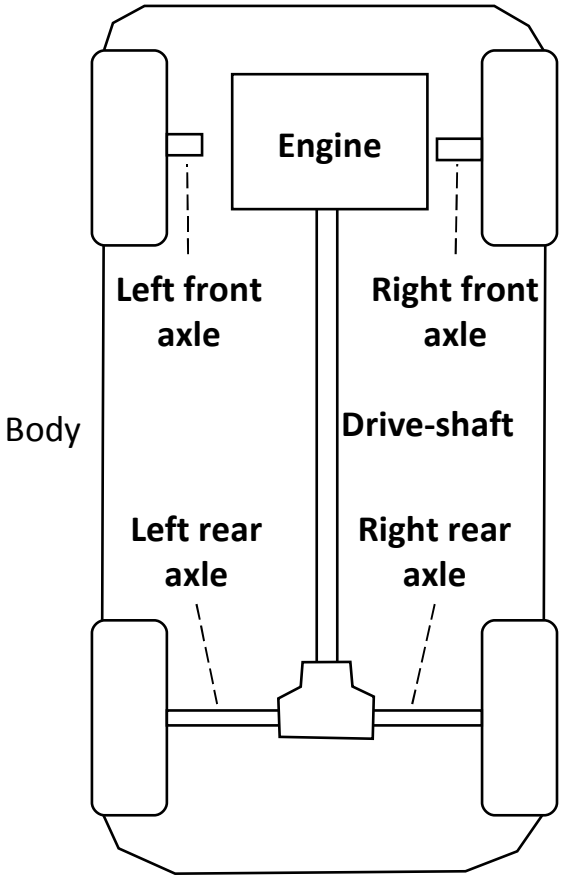
- Opacity of occluding geometry is modulated

Ghosted Views

- Handcrafted 2D (2.5D) images
- Communicates shape of each part
- Communicates spatial and topological relations



Example



Example

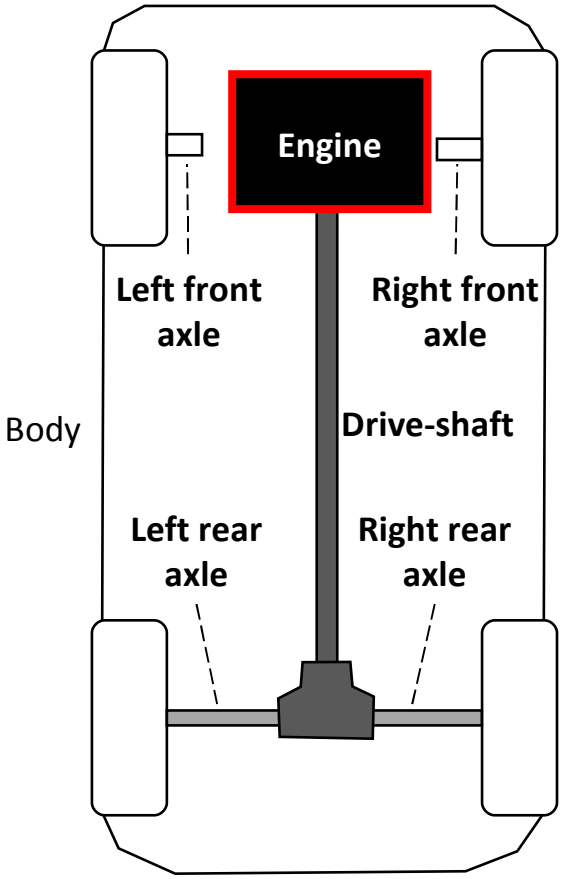


Image courtesy of Kevin Hulsey Illustration, Inc.

Our Solution

- Formally represent relations between parts of the 3D model
- Utilize the relations between objects to expose internal structures
- Utilize the relations to emphasize objects according to focus of the user

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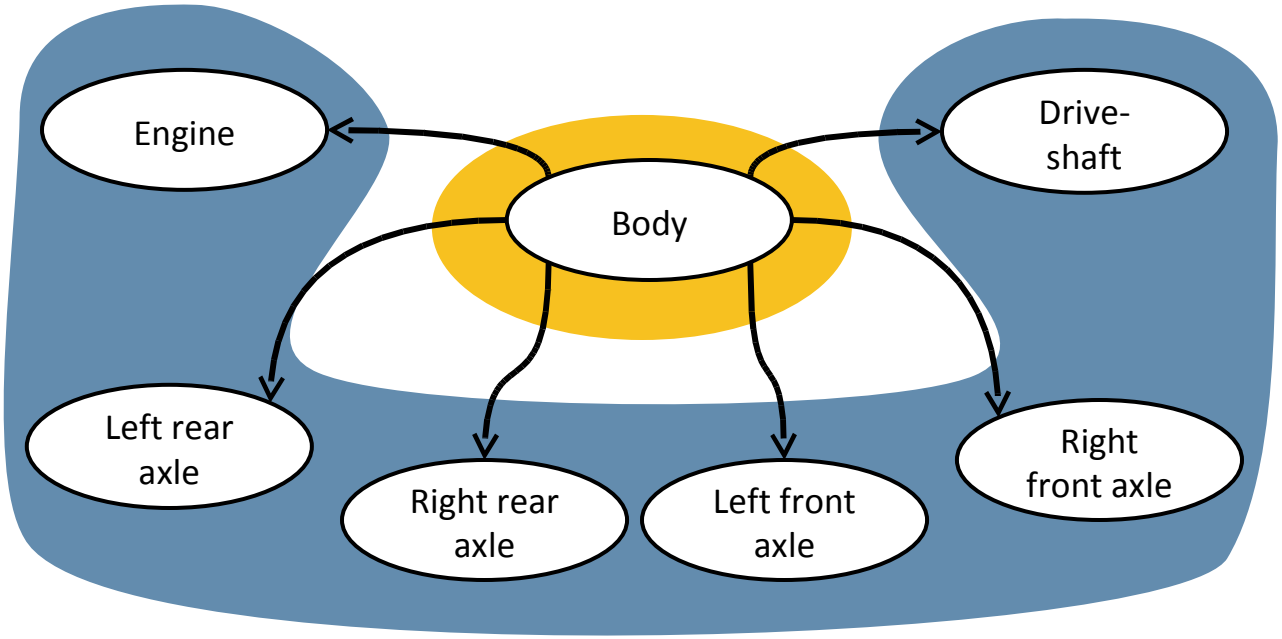
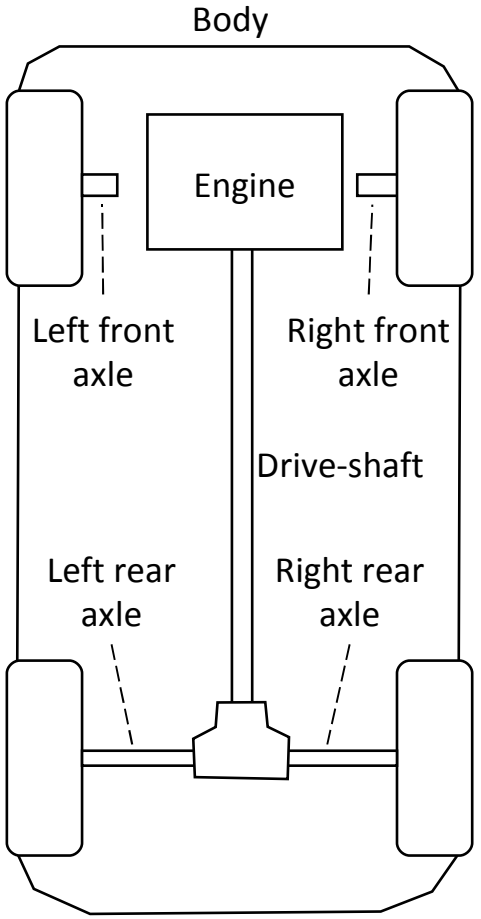
Exposing internal structures

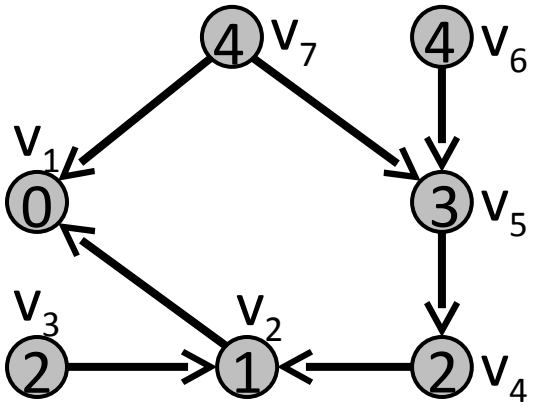
- Contains relation (A contains B)



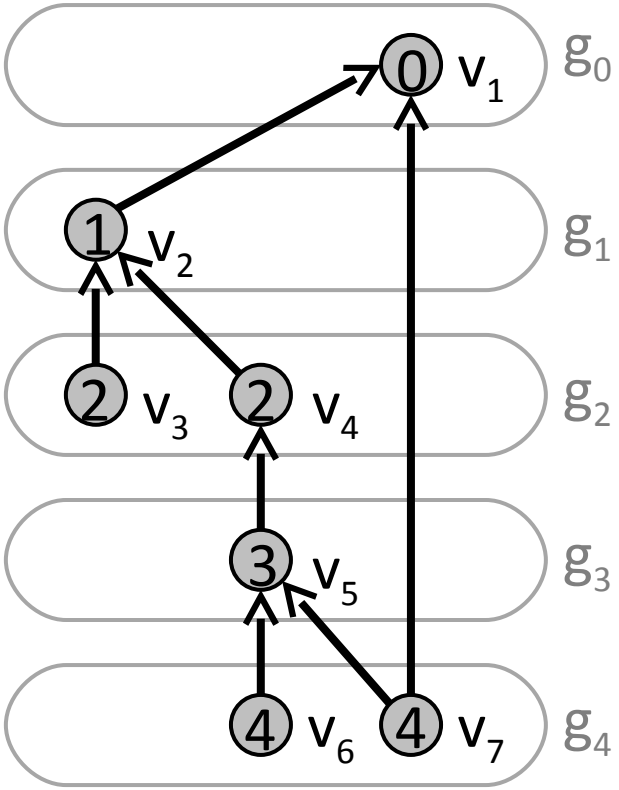


Rendering order

- Correct visualization of transparency
  - Back-to-front compositing

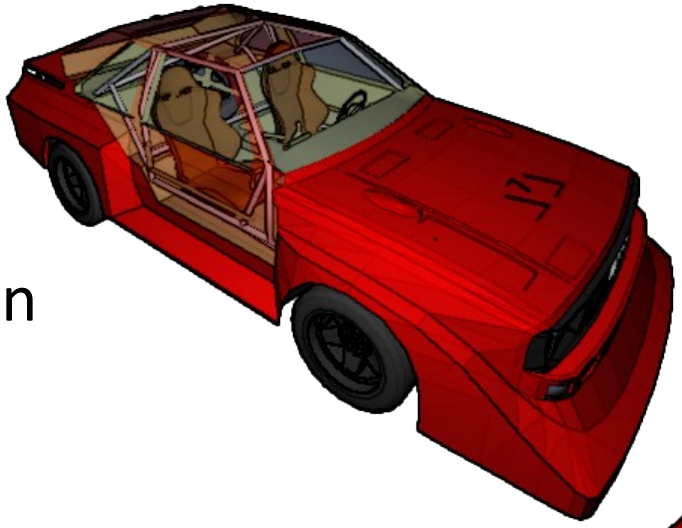


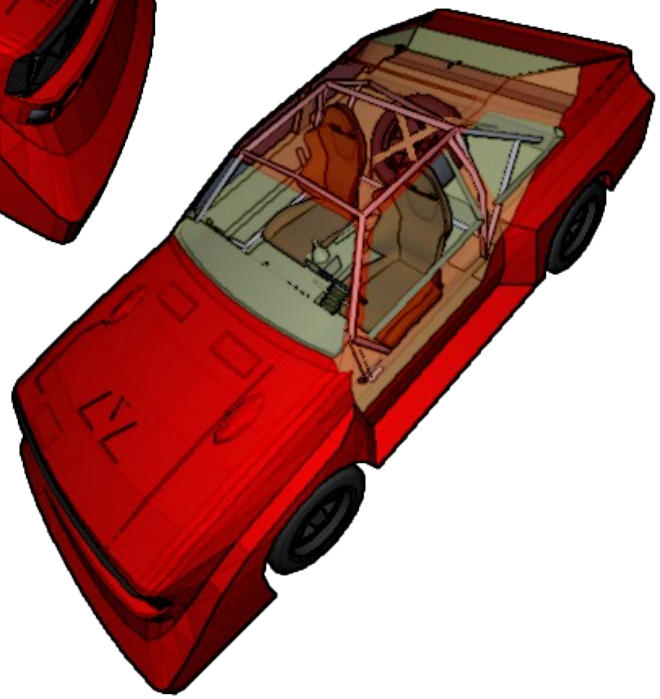
No cycles allowed (DAG)



Results 1/2

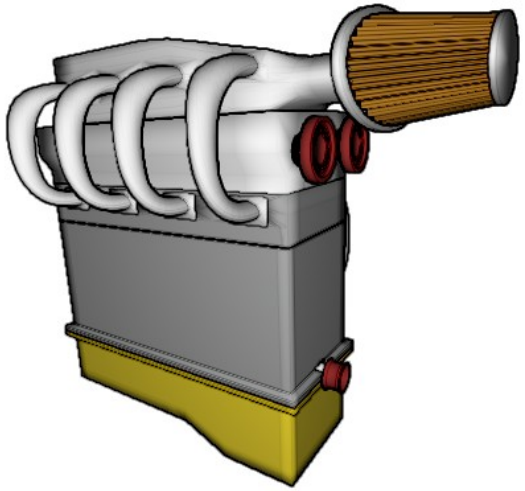
- 29 objects (parts)
- 8 149 faces
- 3 levels
- 512x512 resolution
- 29 fps

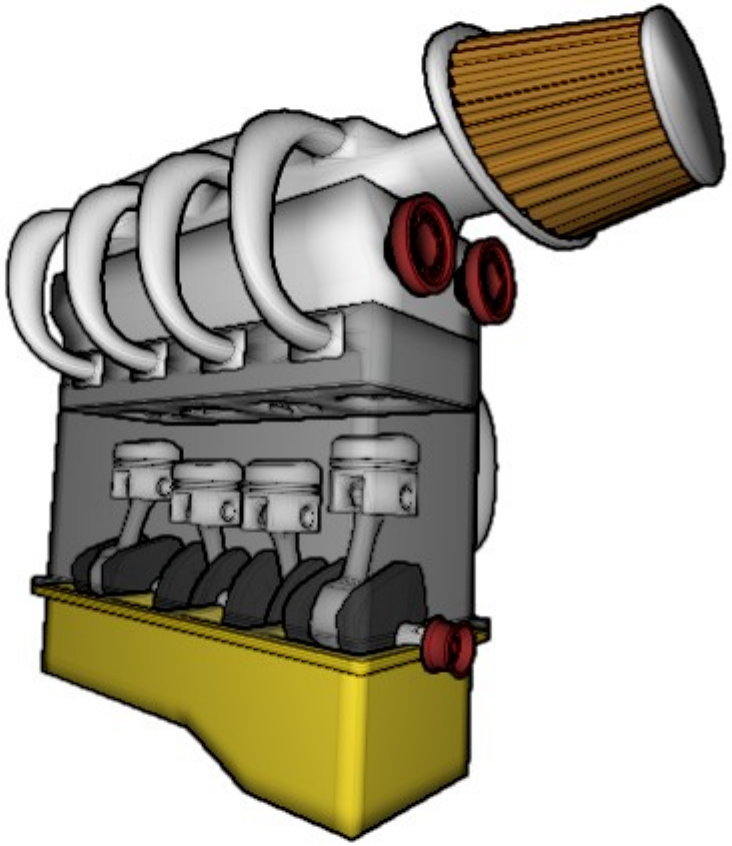




Results 2/2

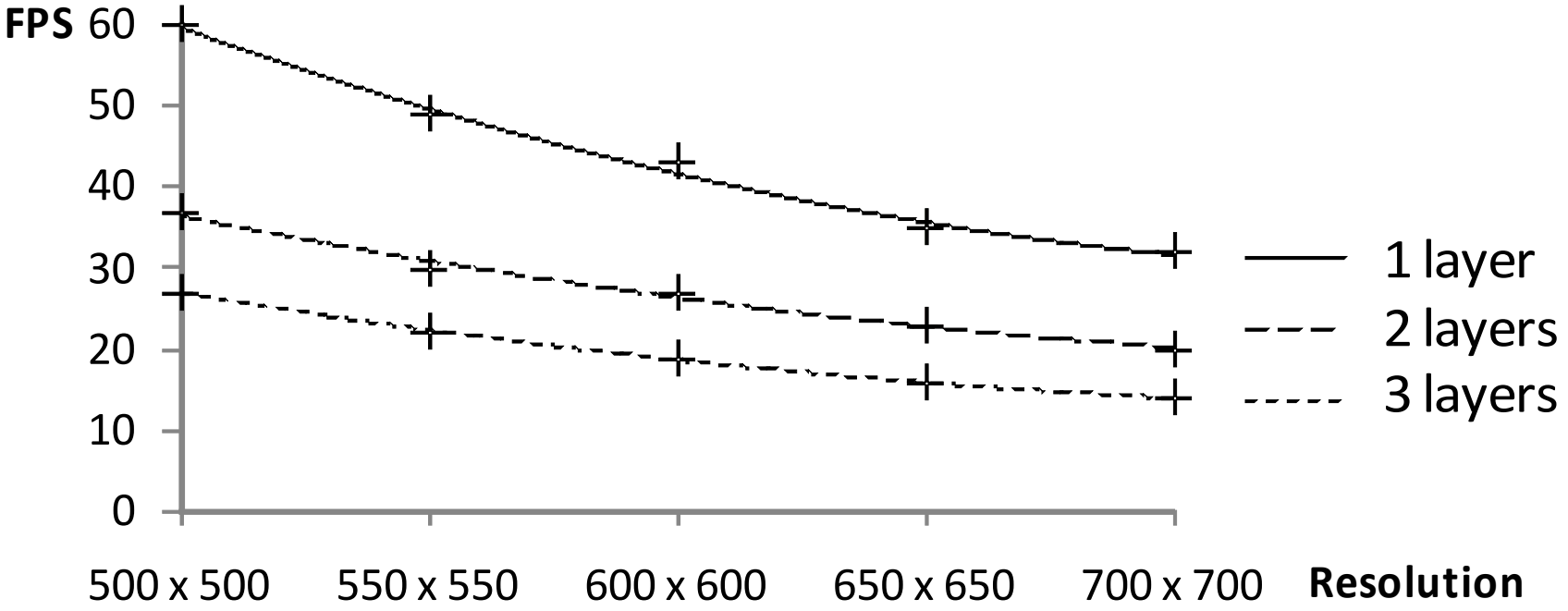
- 65 objects (parts)
- 103 046 faces
- 3 levels
- 512x512 resolution
- 29 fps





Performance

- Scales very good with number of faces
- Depends on number of layers and on resolution
  - Tested on GPU with 16 stream units



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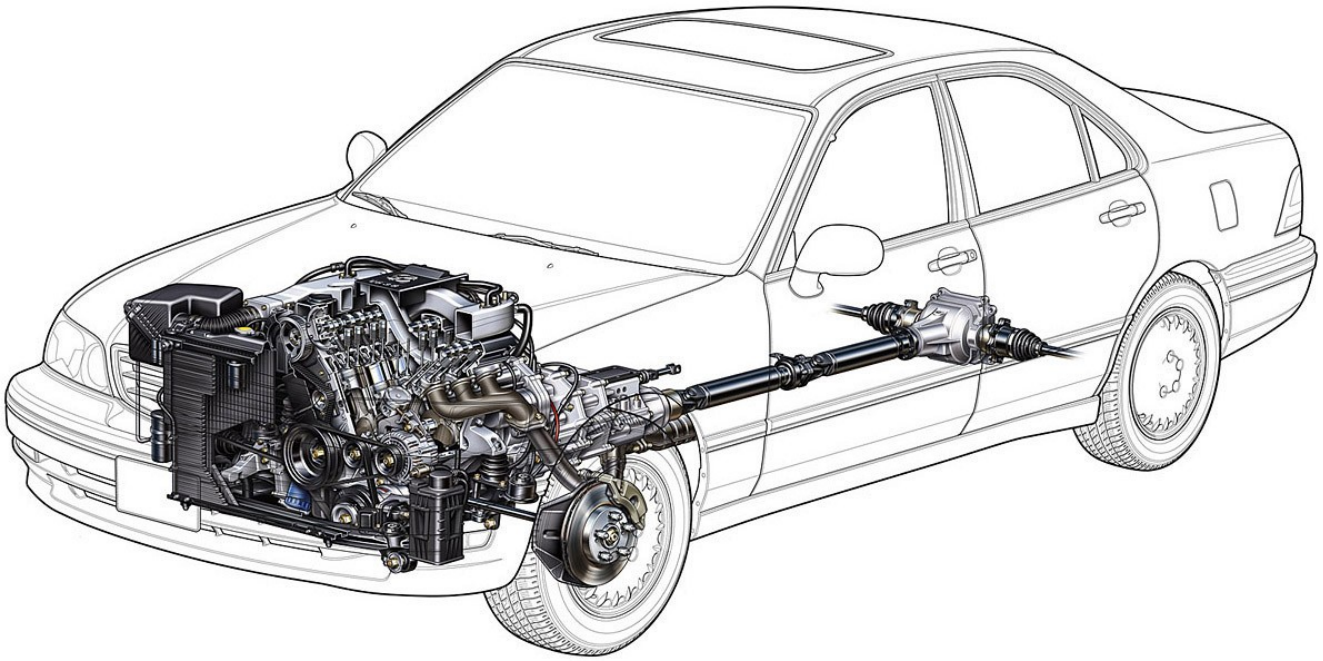
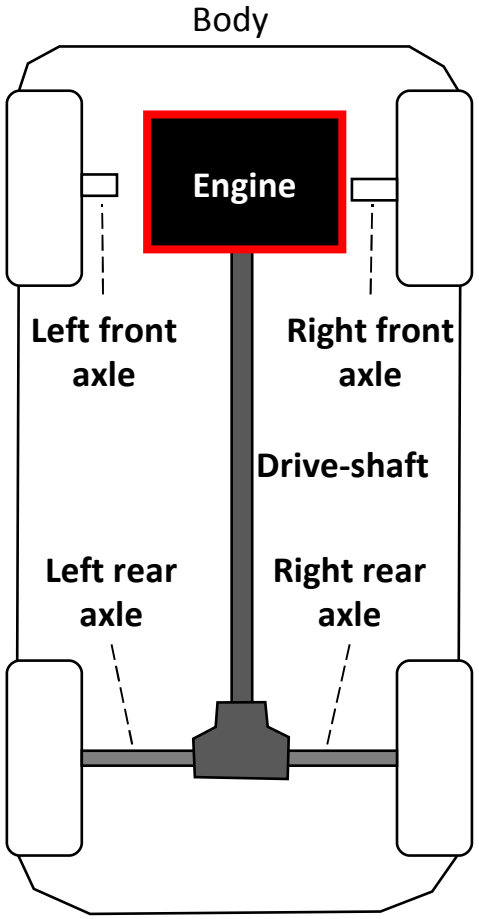
- Utilize the relations to emphasize objects according to focus of the user

Focus of the user

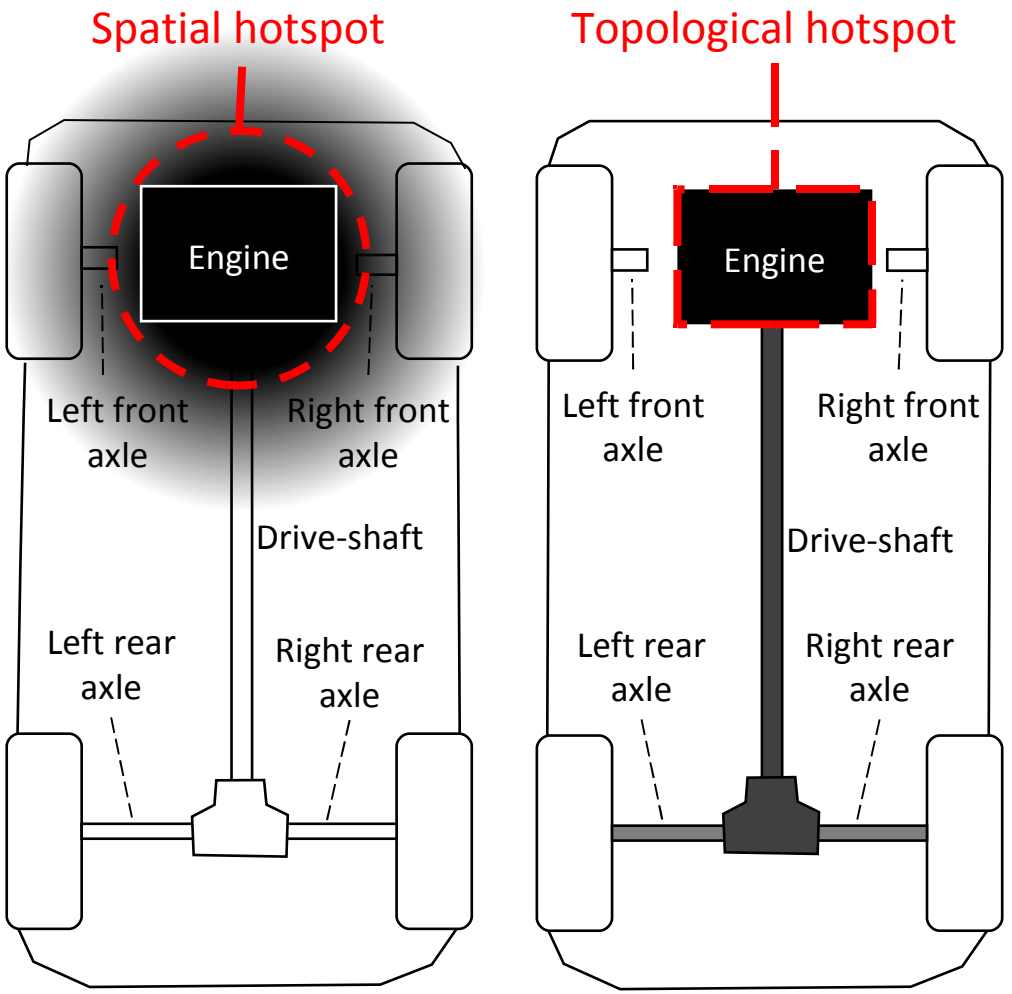
- Topological hotspot
  - Defines focus of the user
  - Topological relations between objects





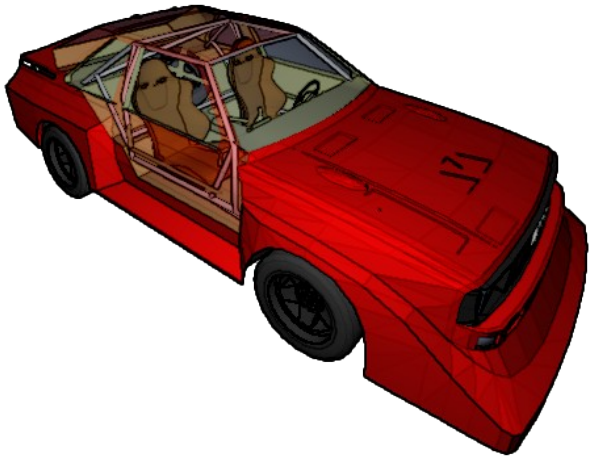
Comparison with Spatial Hotspot

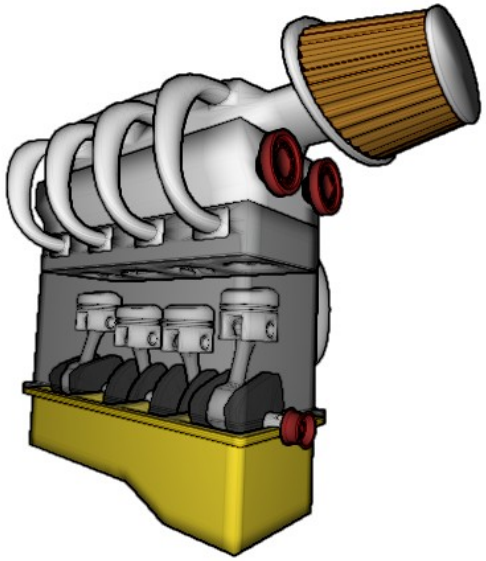
- Spatial hotspot
  [Krüger et al. 2006]
  - Utilizes spatial relations
- Topological hotspot
  - Utilizes topological relations
- Combination of spatial and topological hotspot?



Conclusion

- Problems related to exploration of 3D models have been analyzed.
- Novel method for exposing internal structures has been developed
- Concept of topological hotspot has been introduced
- Future Work
  - Implement topological hotspot
  - Implement labeling of the 3D model
  - Create tools that allow fast annotation of 3D models
  - Testing with users



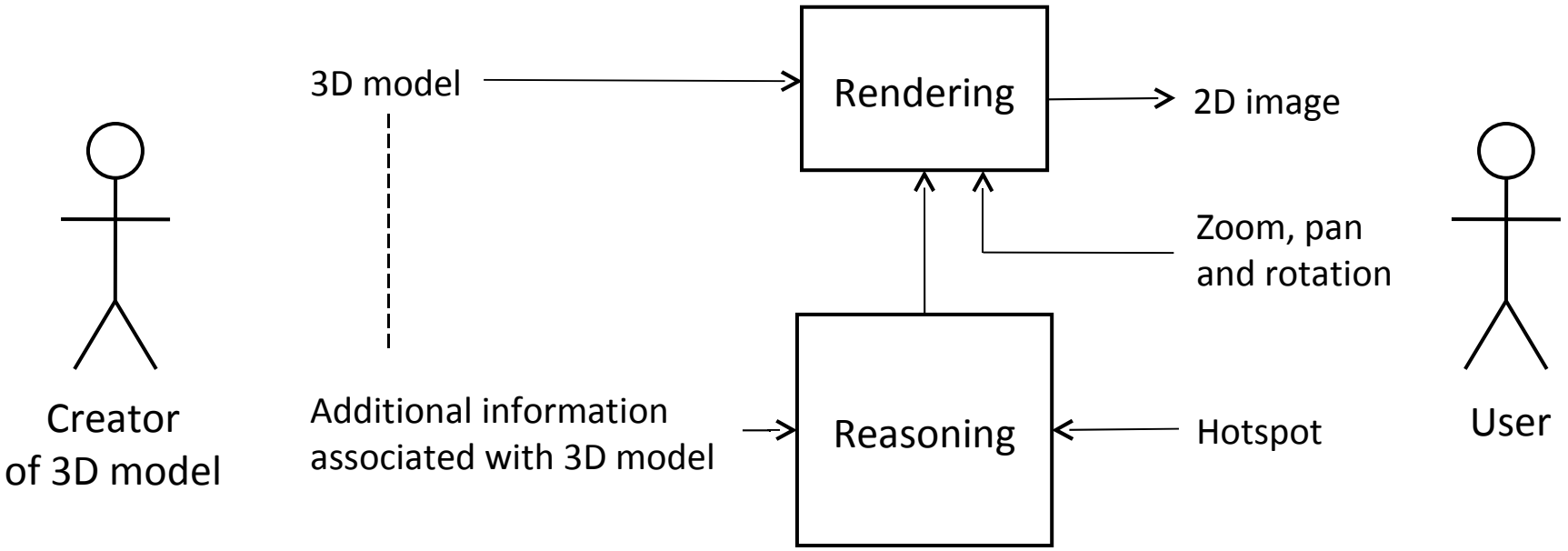


Thank you for your attention.

Discussion

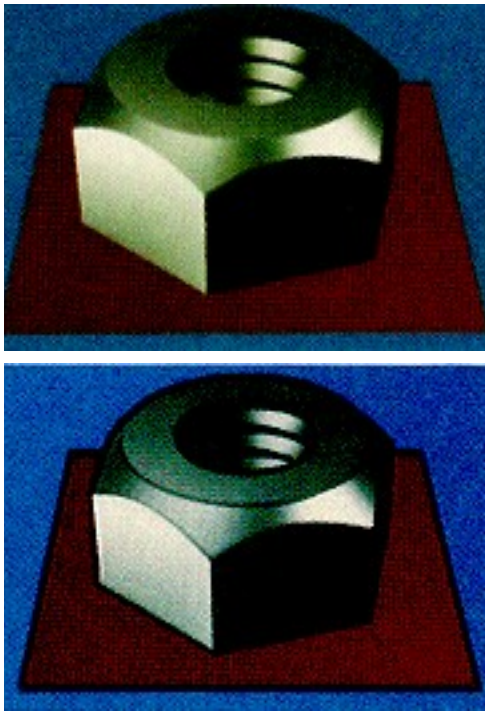
Computer Graphics Group

Overview of Our Solution

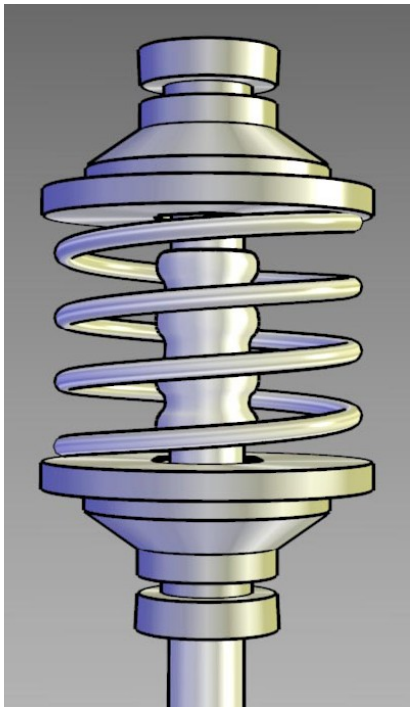


Automated technical illustration

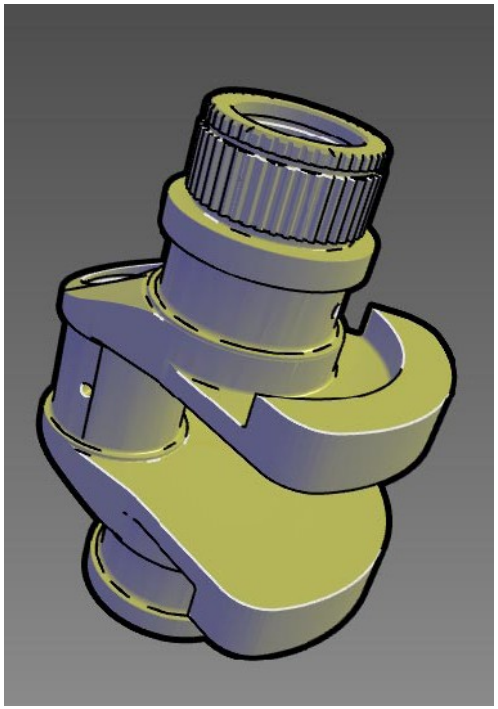
- Communication of shape



[Saito et al. 1990]



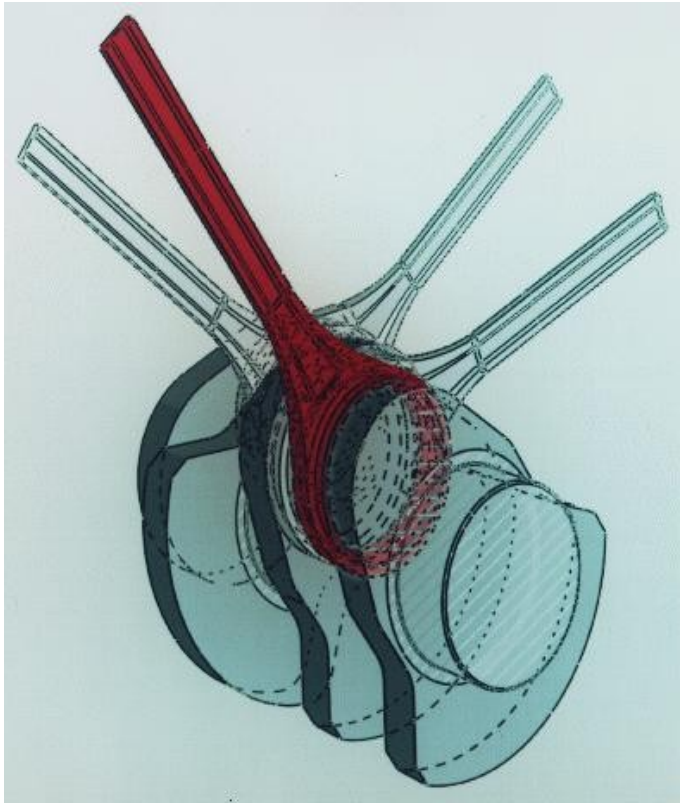
[Gooch et al. 1998]



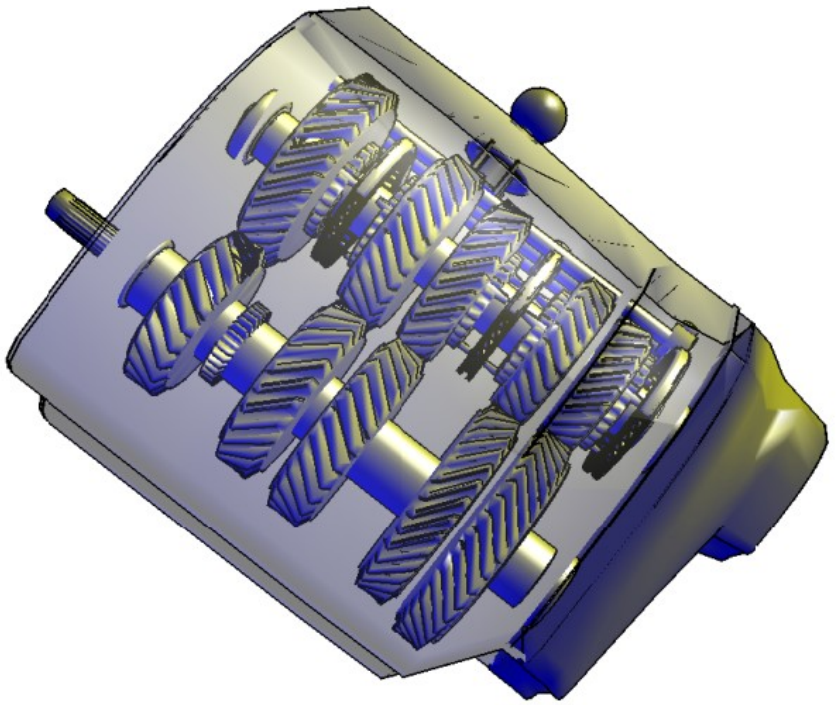
[Gooch et al. 1999]

Automated technical illustration

- Communication of structure



[Dooley and Cohen 1990]



[Diepstraten et al. 2002]

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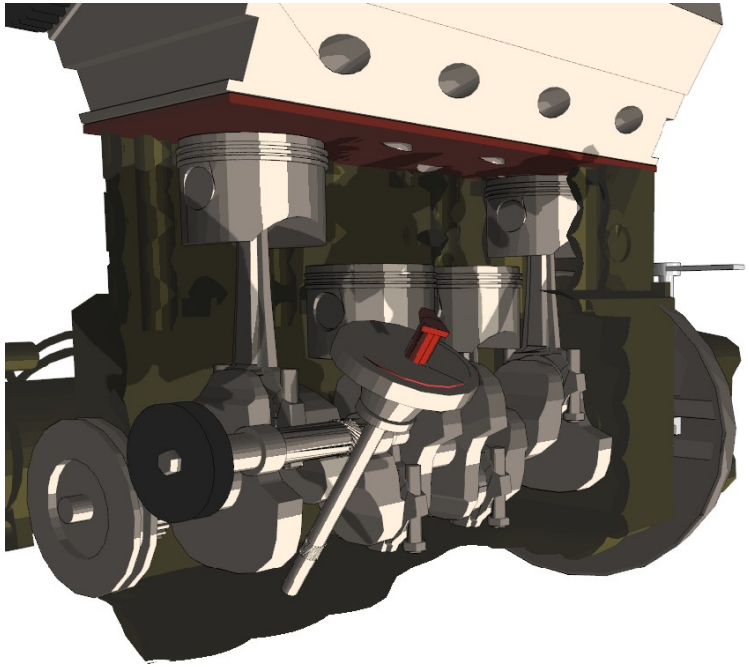
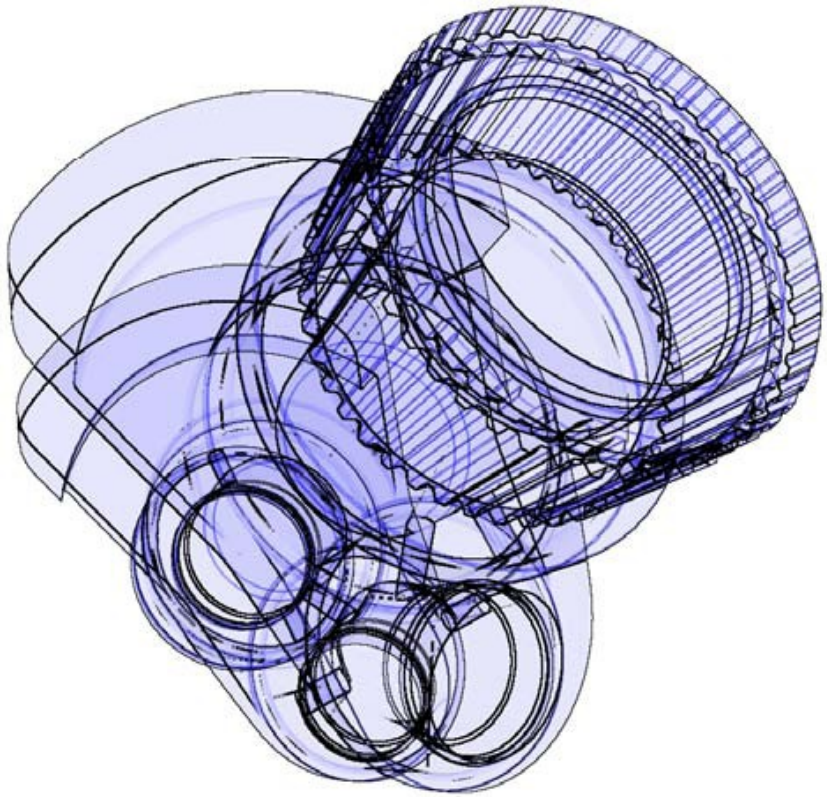


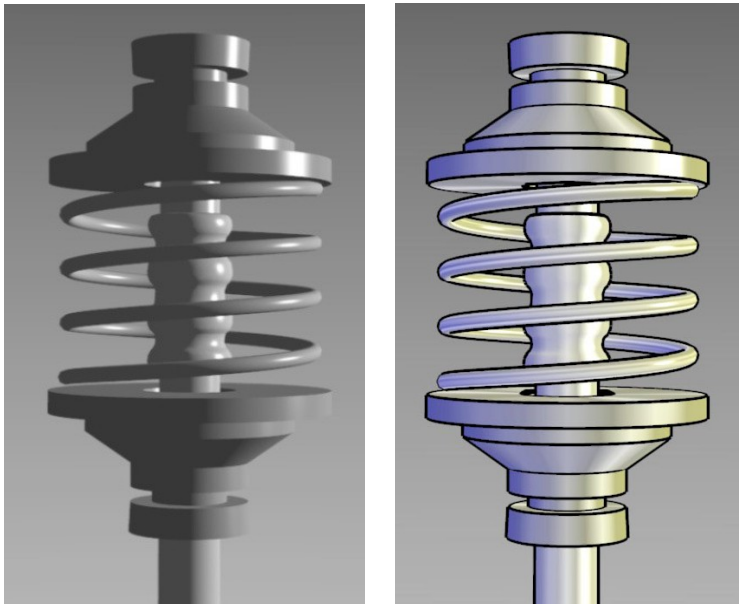
[Diepstraten et al. 2003]



[Nienhaus and Döllner 2004]

Automated Technical Illustration

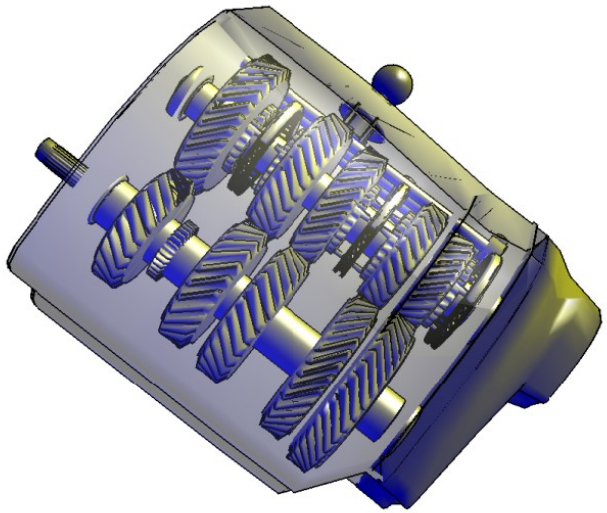
- Communication of shape
  - Emphasis of silhouettes and important interior edge lines
  - Non-photorealistic shading
- Unable to reveal the inner structure
- Very limited interaction (zoom, pan, rotation)



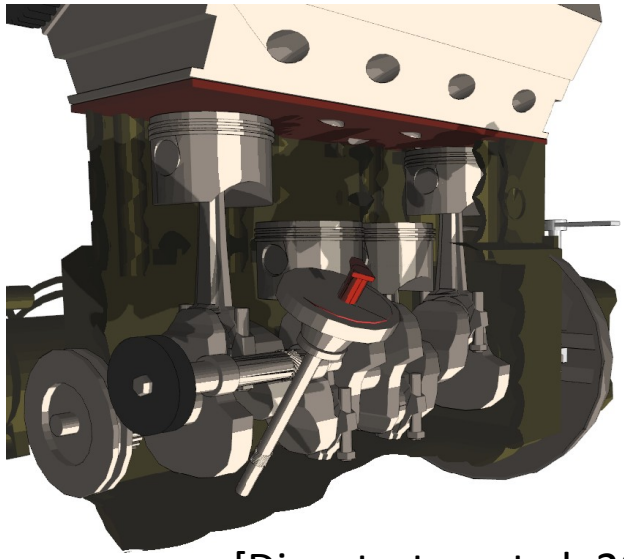
[Gooch et al. 1998]

Automated Technical Illustration

- Communication of structure
  - Use of transparency
  - Cut-away views
- Only spatial relations between objects are utilized
- Limited interaction – user cannot focus on different parts



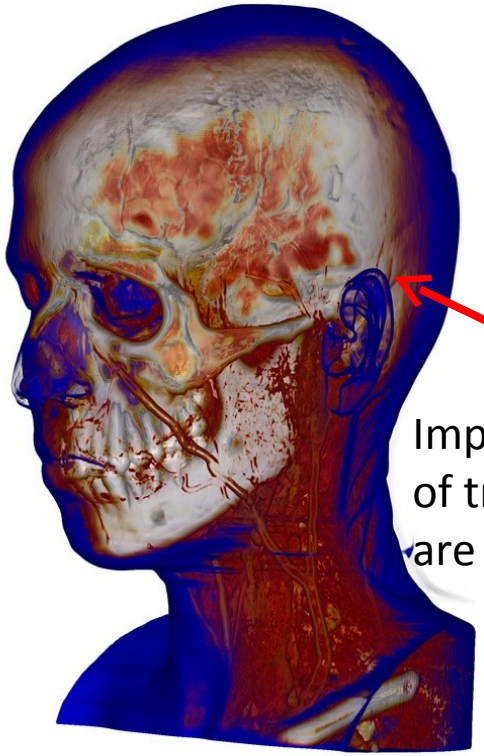
[Diepstraten et al. 2002]



[Diepstraten et al. 2003]

Context-preserving Rendering

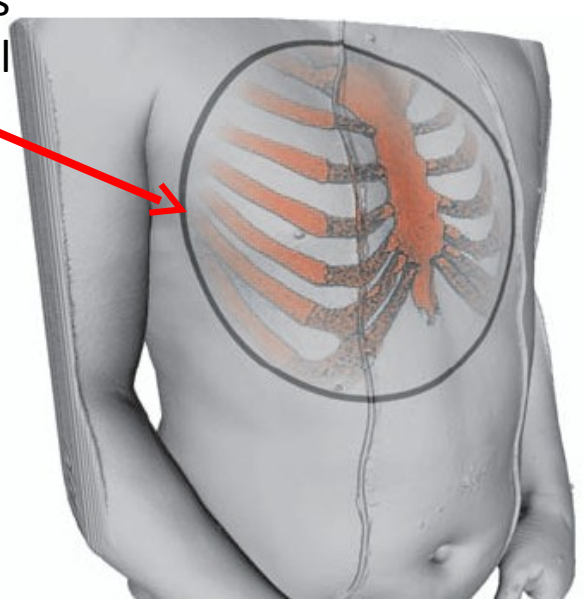
- Preserves contextual information of objects under the focus
- Designed for volumetric data sets
- Only spatial relations between objects are utilized



Important features of transparent objects are preserved

[Bruckner et al. 2005]

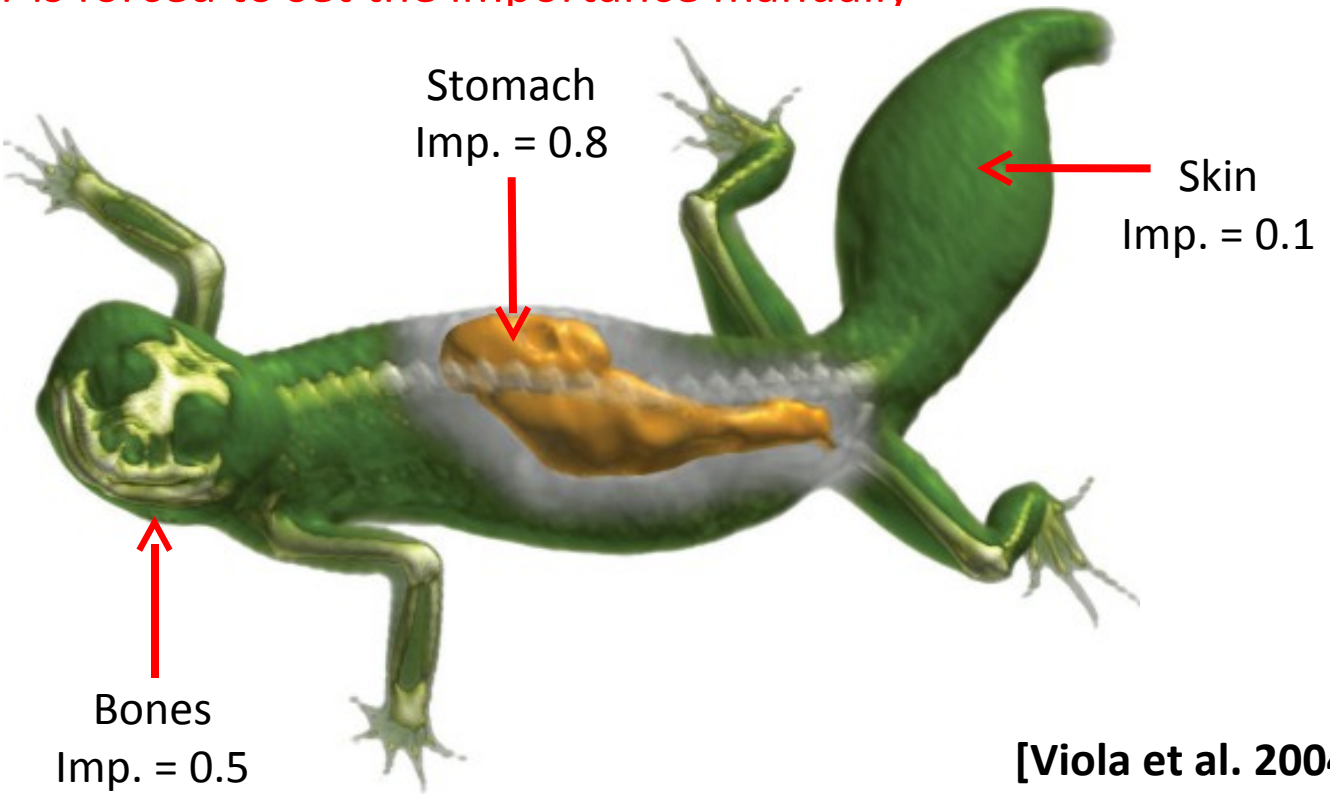
User specify her/his focus with spherical hotspot



[Krüger et al. 2006]

Importance-driven Rendering

- Utilizes importance of objects in the rendering process
- User has very good control of the final visualization
- Designed for volumetric data sets
- User is forced to set the importance manually



[Viola et al. 2004]