Future Challenges in Computer Graphics

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What This Talk Is About

- overview of some current research trends & exploration of challenges in 3 subfields of CG:

interactive and photorealistic rendering

visualization **visual analytics**

- 5 challenges play a role in all these areas:

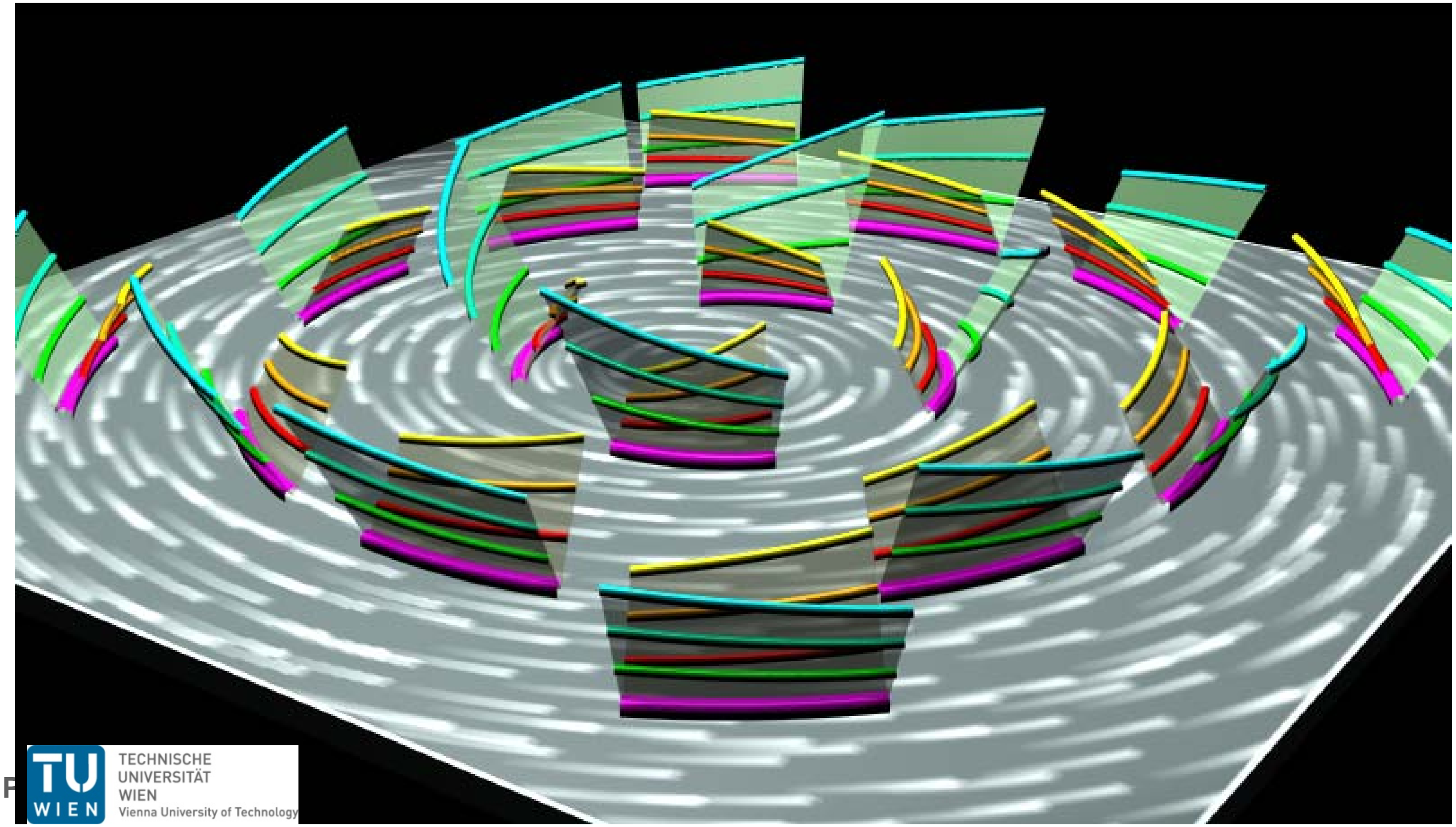
scalability
semantics
fusion
interaction
acquisition

Interactive and Photorealistic Rendering

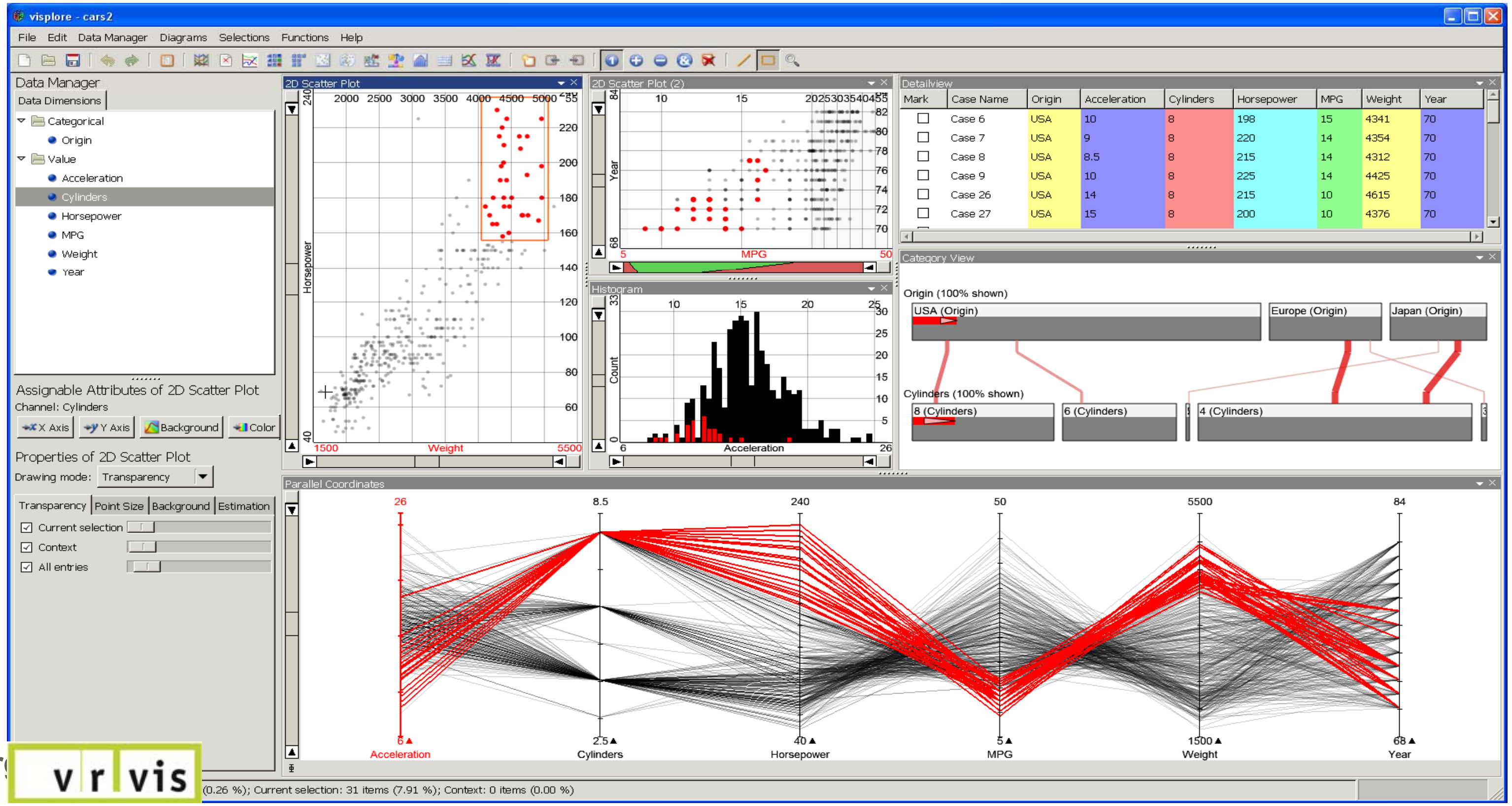
- goal of rendering research is to create perfectly realistic looking images of real-world objects in real-time

Visualization

- visualization tries to create images of data and structures that are otherwise invisible to the human eye or completely abstract



- combination of information visualization and scientific visualization
- focuses on analytical reasoning facilitated by interactive visual interfaces



Mark	Case Name	Origin	Acceleration	Cylinders	Horsepower	MPG	Weight	Year
☐	Case 6	USA	10	8	198	15	4341	70
☐	Case 7	USA	9	8	220	14	4354	70
☐	Case 8	USA	8.5	8	215	14	4312	70
☐	Case 9	USA	10	8	225	14	4425	70
☐	Case 26	USA	14	8	215	10	4615	70
☐	Case 27	USA	15	8	200	10	4376	70

Success of Computer Graphics

- High technology level !
  - one the most successful computer science fields during the last three centuries
  - methods and results available today have exceeded the expectations by far
  - some people consider most computer graphics problems as solved
- But:
  - ready to use set of tools for applications only in some areas with simple use of images
  - embedding of CG in increasingly complex sur-roundings generates many new challenges.

5 Challenges

- 1 – Scalability
- 2 – Semantics
- 3 – Fusion
- 4 – Interaction
- 5 – Acquisition

1 – Scalability

- how to cope with huge amounts of data, highly parallel computers and distributed devices
- example: reconstruction from many photos

Scalability Challenges

- enormous ***amounts of data*** (peta-scale!)
  - today and even more in the future
  - memory grows faster than speed
  - bottleneck: data transfer
- many existing algorithms are not designed to grow so much
- we need fundamental research on
  - scalable algorithms
  - scalable techniques
  - scalable systems

Scalability Challenges

- increasingly ***complicated data***
  - 3D reconstruction
  - segmentation
  - object identification
- → <u>parallelization and distributed computing</u>
  - multi-core CPUs & GPUs
  - shared/distributed memory architectures
  - computation & visualization clusters
  - remote computation & visualization
  - cloud computing
- → <u>multi-resolution approaches</u>
  - semantic information at various scale levels

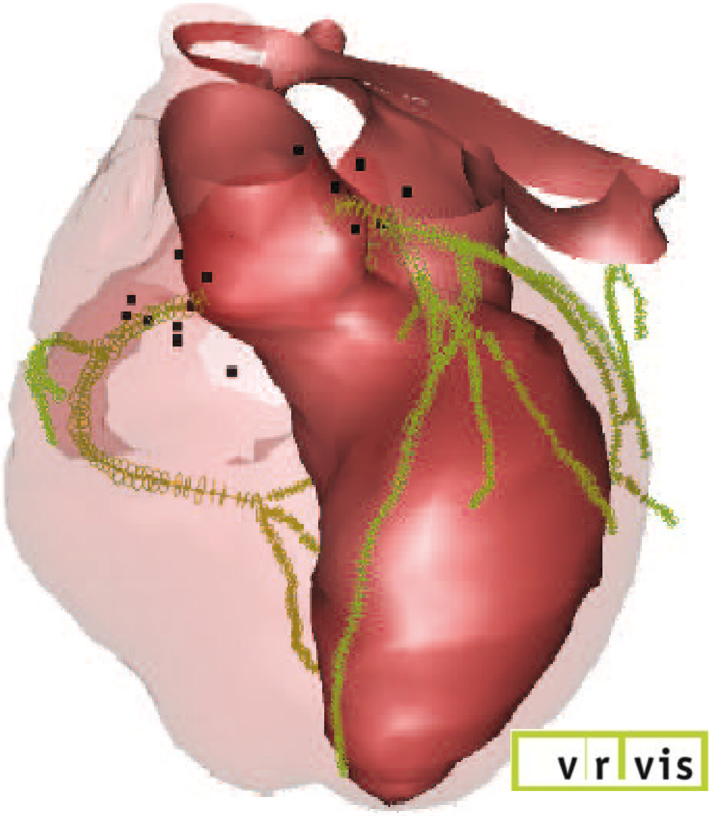
Scalability Challenges

- increasingly ***diverse devices***
  - algorithms and interaction techniques have to scale to different possibilities
  - includes multi-display devices

- increasingly ***more users***
  - new interaction techniques for multi-user applications

2 – Semantics

- how can meaning be extracted from data and context and be used for better insight
- example: segmenting of data



Semantics Challenges

- more semantic data information necessary
  - for interpretation & analysis
  - for intelligent queries with semantic criteria
- ***semantic criteria*** can be based on
  - underlying data
  - analysis goals
  - application scenario
  - use history
  - user profile

Semantics Challenges

- semantically enriched data allow for
  - context (audience) based visualizations
  - data compression
- ***goals***
  - extract semantic information from data sets (huge, heterogeneous, unstructured)
    - atlasses, matching methods, sharing of insight
  - find data structures for semantic information
    - flexible to include new knowledge
  - extend rendering methods to use semantic inf.

Semantics Challenges

- semantics will enable ***new user interfaces***
  - in application domain (for application experts)
  - instead of data domain (for computer experts)
- semantics topics of ***research in visualization***
  - knowledge-assisted visualization
  - knowledge-based navigation
  - semantics steered feature extraction

Semantics Challenges

- semantics topics of ***research in rendering***
  - enabling of contextual decisions
  - internal representation
    - highly abstract representation
    - distinguishing parameters are sufficient
    - know-how encoded in class description
    - more than just procedural modeling/rendering

3 – Fusion

- how can multiple techniques, data streams, and models be combined to solve complex problems
- example: combination of various data sources

Fusion Challenges

- ***fusion issues***
  - multiple fields of visual computing
    - various display methods
    - integration of vision with rendering
  - visual computing with other computing fields
    - integration instead of pre- or post-process
  - multiple data sources
    - various scanning methodologies
    - measured and simulated data
    - structured and unstructured data

4 – Interaction

- how to combine multiple and ubiquitous input devices to create ergonomic user interfaces
- example: intuitive interface for untrained users

Interaction Challenges

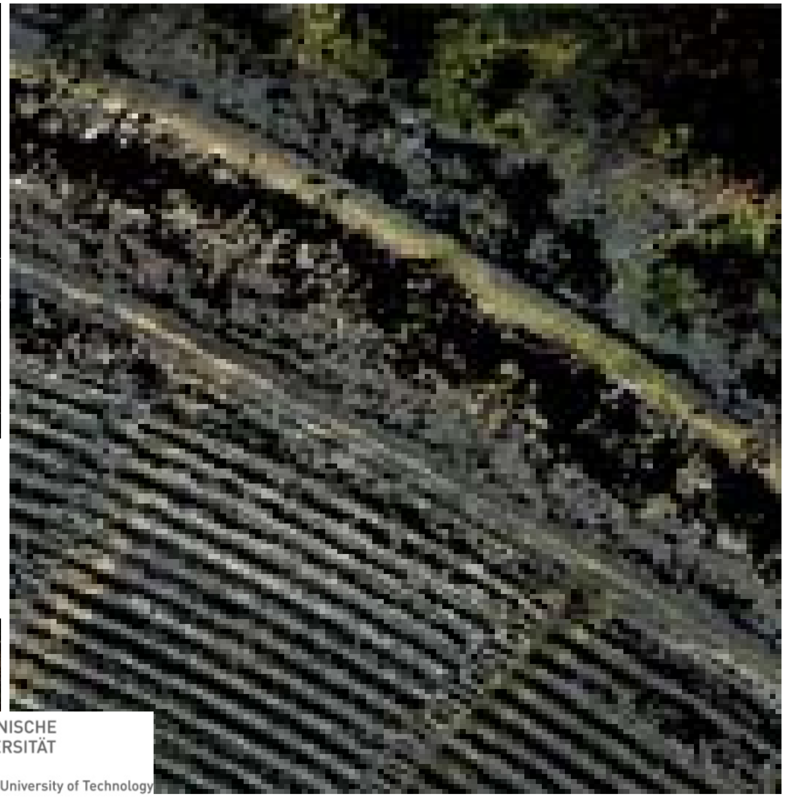
- real-time data exploration and manipulation is more powerful than passive results
- ***emerging interface technologies***
  - face, gesture, speech recognition
  - multi-touch displays
  - optical tracking
  - eye-tracking
  - 3D point clouds
  - EEG-based input
  - ubiquitous systems

Interaction Challenges

- development of new HCI techniques
  - virtual environments
  - tangible user interfaces
  - vision based interaction
- ***adaptation*** of interface ***to target audience***
  - different levels of UIs
  - defined or learned UI level
  - single user or groups of users
  - explicit or pervasive interface

5 – Acquisition

- how can data from various input sources be processed to deal with missing data, contradictions, and uncertainty
- example: reconstruction from laser-scans



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Acquisition Challenges

- analysis and display of ***real world data***
  - diverse measurement techniques
  - measurement errors
  - noise, dropouts, repetition
  - lack of semantic information
  - normally not consistent
  - often incomplete

Acquisition Challenges

- examples of acquisition areas
  - architectural data
  - laser scans, photogrammetric data
  - medical and industrial data
  - CT, MRI, X-ray, ultrasound
  - geometry from depth images
  - GPS, GSM triangulation
  - satellite images
  - computer vision methods

Acquisition Challenges

- ***challenges***
  - generate consistent, unambiguous models from hybrid measurement data
  - interpolation of gaps
    - statistically valid   or
    - empirically valid
  - correction of known technology artifacts
  - reduce data volume
  - create representations for the next step

Summary

- many simple visual computing problems are solved
- but: the embedding of computer graphics technology in increasingly complex surroun-dings generates many new challenges.
- five major challenges are orthogonal to the traditional computer graphics fields: scalability, semantics, fusion, interaction, and acquisition.
- many open research issues

Thank You for Your Attention!

Questions?