KIVI Engineering Society

KIVI Chair - Big Data Science Master Class

Computer Graphics and Visualization

prof.dr. Elmar Eisemann

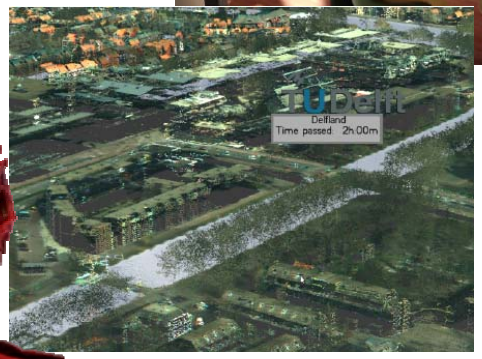
10 November 2016

DELFT DATA SCIENCE

[Ritschel, Eisemann, Ha, Kim, Seidel - CGF 2011]
[Kehl, de Haan – Gi4DM 2012]
[Kroes, Post, Botha -PLoS ONE 2012]

Introduction

- Computer Graphics has many applications
  - Architecture/Design
  - Scientific visualization
  - Simulation
  - Education
  - Movies
  - Games
  - …



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TU Delft - Computer Graphics and Visualization

Prof. Dr. Elmar Eisemann

Dr. Rafael Bidarra

Dr. Anna Vilanova

Dr. Klaus Hildebrandt

Faculty

- Postdocs, PhDs, Master students
- Many external collaborators…

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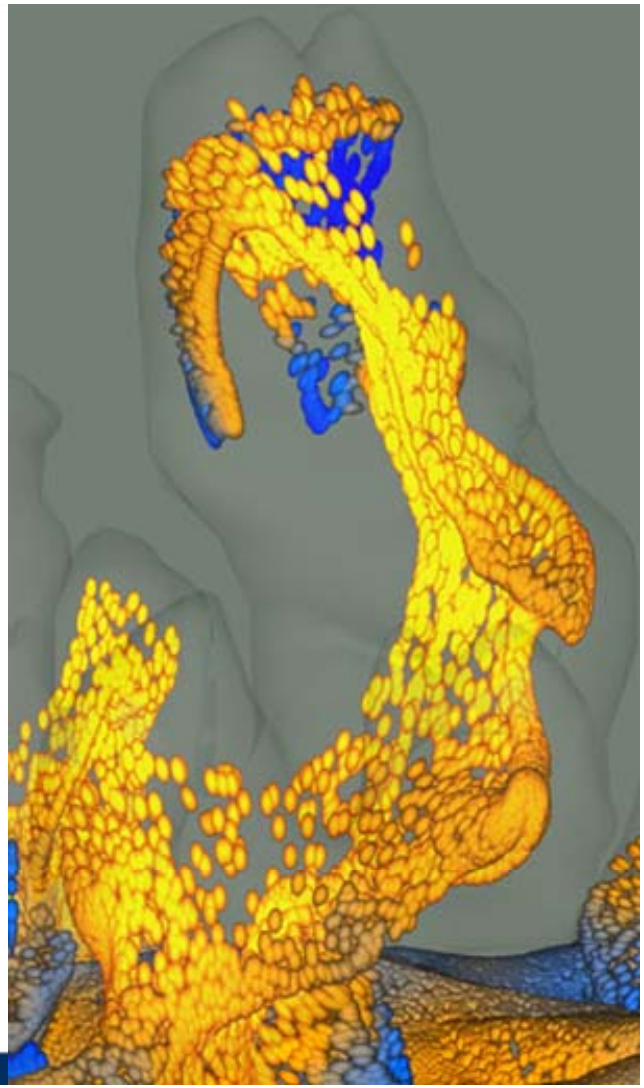
What do we do?

- Game Technology
- Geometry Processing
- Rendering Techniques
- Data/Medical Visualization



Game Technology

- Automatic Content Generation
- Serious Gaming

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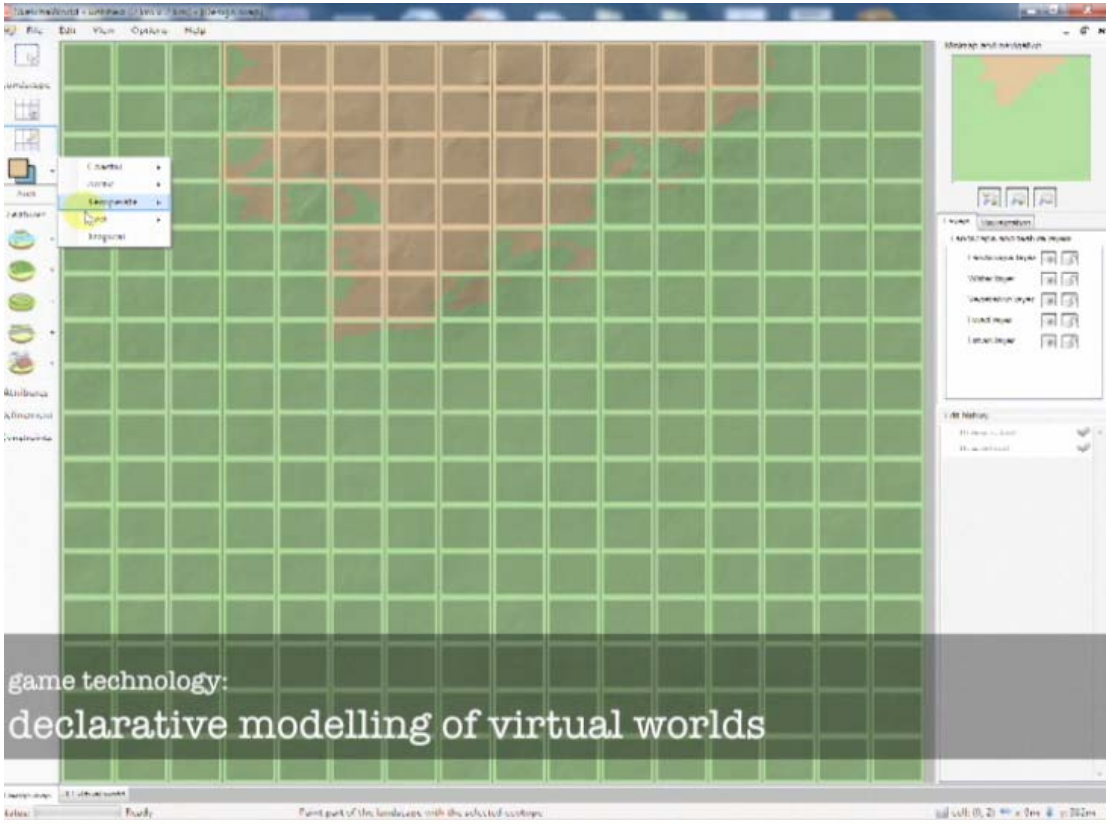
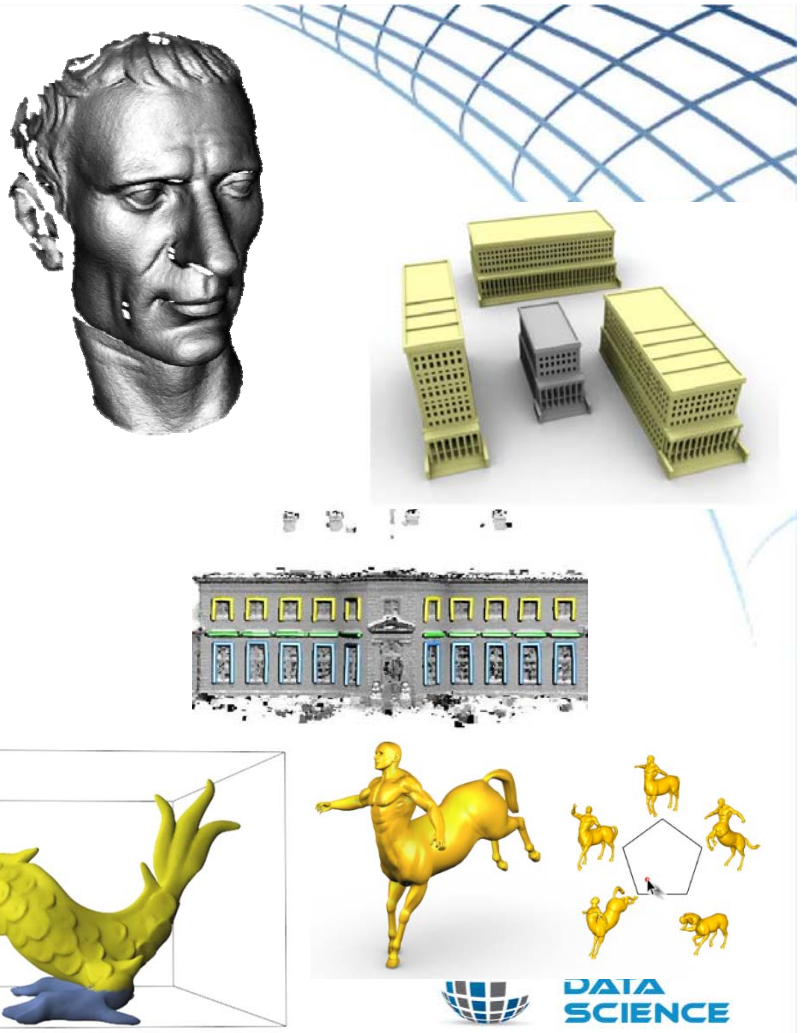
[Smelik, Tutenel, Kraker, Bidarra– EG S 2012]

Content Creation



Geometry Processing

- Geometric Models
  - Shape Analysis and Synthesis
- Reconstruction and Recognition
- Animation
  and Deformation



[Thiery, Guy, Boubekeur, Eisemann – TOG 2016]

Extract Minimal Motion Representations

input mesh

sphere-mesh

interpolated sphere-mesh

- Interactive level-of-detail control

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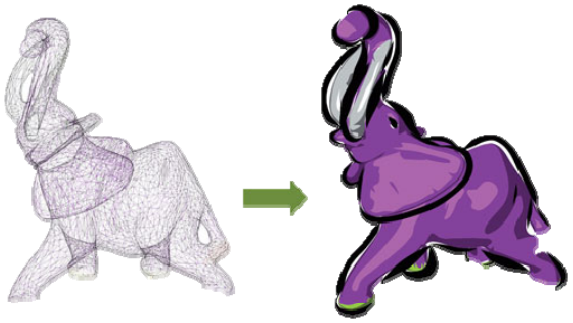
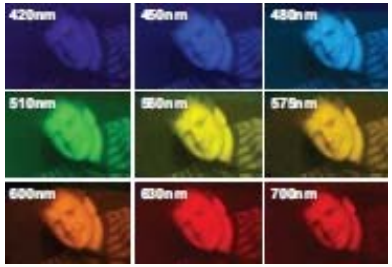
Rendering Techniques

- Realistic rendering
  (Shadows, Shading, global illumination)
- Non-photorealistic Rendering
- Perceptual rendering & more…
- Computational Photography





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Global Illumination via
[Crassin, Neyret, Sainz, Green, Eisemann, PG 2012]

Global Illumination

Unreal Engine 4

Epic Games

2016

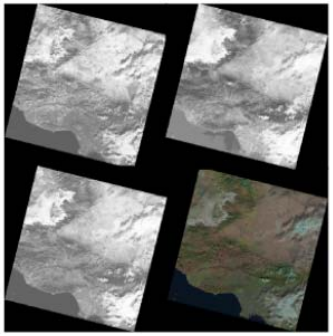
e.g., shipping in

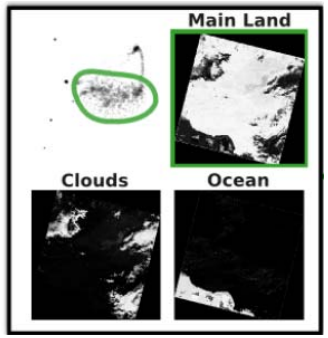
Tomb Raider

In all examples
SM resolution: 1024x1024
scattering: < 3 ms
[Klehm,Seidel,Eisemann i3D2013]
[Klehm,Seidel,Eisemann jcgt2014]

Data and Medical Visualization

- Large-Scale Data Display
- Interaction Methods
- Visual Analytics
- Medical Visualization





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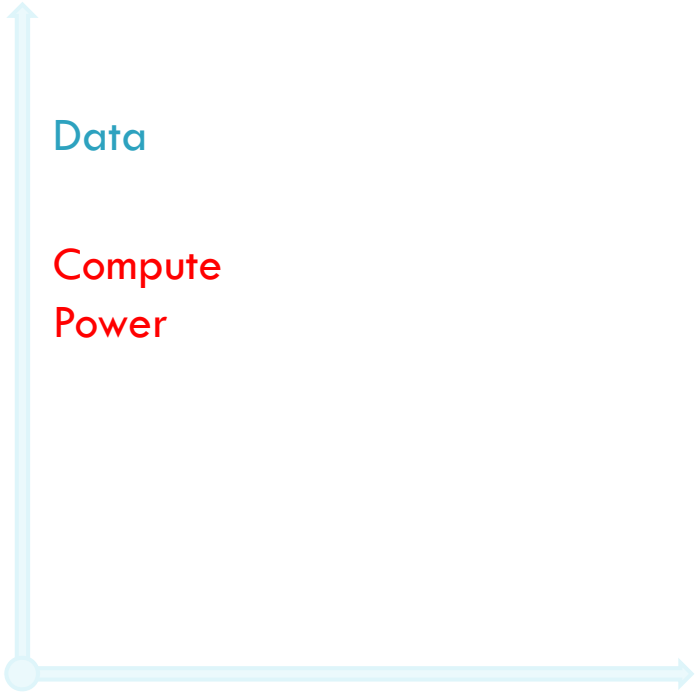
Data Development

- **Processing**
- **Analysis**
- **Interaction**
- **Visualization**
- **Guidance**



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Data Analysis?

- SALEM OR 46 67 RAIN 52/61 RAIN 50/60 SALT LAKE CITY 58 86 PTCLDY 56/85 PTCLDY 54/78 SAN ANGELO 67 86 MOCLDY 68/91 PTCLDY 69/92 SAN ANTONIO 68 82 9.87 MOCLDY 71/89 MOCLDY 70/91 SAN DIEGO 60 68 MOCLDY 60/67 MOCLDY 61/68 SAN FRANCISCO 50 60 WINDY 53/62 MOCLDY 52/64 SAN JOSE 47 68 PTCLDY 52/69 MOCLDY 52/68 SAN JUAN PR 75 89 .55 SHWRS 77/87 SHWRS 78/85 SANTA FE 52 87 SUNNY 51/86 PTCLDY 48/83 ST STE MARIE 34 60 SUNNY 36/65 SUNNY 34/72 SAVANNAH 53 80 PTCLDY 53/84 PTCLDY 60/85 SEATTLE 51 64 CLOUDY 50/64 CLOUDY 51/64 SHREVEPORT 68 88 MOCLDY 69/87 PTCLDY 66/88 SIOUX CITY 56 72 .01 MOCLDY 61/78 MOCLDY 64/77 SIOUX FALLS 56 74 TSTRMS 56/73 MOCLDY 60/75 SOUTH BEND 39 66 MOCLDY 47/66 SHWRS 51/69 SPOKANE 40 61 MOCLDY 44/67 MOCLDY 47/66 SPRINGFIELD IL 47 58 .46 TSTRMS 53/72 TSTRMS 61/78 SPRINGFIELD MO 56 80 MOCLDY 62/80 PTCLDY 63/82 SYRACUSE 43 57 SUNNY 40/63 SUNNY 39/68 TALLAHASSEE 55 89 SUNNY 56/88 PTCLDY 62/90 TAMPA 73 92 SUNNY 67/89 PTCLDY 69/88 TOLEDO 36 66 PTCLDY 41/67 MOCLDY 44/69 TOPEKA 64 84 MOCLDY 66/83 WINDY 66/85 TUCSON 67 97 SUNNY 65/96 SUNNY 63/95 TULSA 64 84 MOCLDY 70/83 MOCLDY 69/85 TUPELO 51 82 PTCLDY 56/86 PTCLDY 61/87 WACO 67 84 MM MOCLDY 68/86 MOCLDY 67/88 WASHINGTON DC 46 68 SUNNY 47/73 SUNNY 50/77 W PALM BEACH 75 83 PTCLDY 72/82 PTCLDY 73/83 WICHITA 66 83 PTCLDY 65/85 WINDY 67/86 WICHITA FALLS 67 82 .11 WINDY 65/91 WINDY 66/92 WILKES BARRE 42 56 .15 SUNNY 39/65 SUNNY 37/72 WILMINGTON DE 47 65 SUNNY 44/71 SUNNY 46/77 YAKIMA 41 70 MOCLDY 46/63 MOCLDY 48/65 YOUNGSTOWN 30 61 SUNNY 33/64 SUNNY 34/70 YUMA 70 98 SUNNY 66/97 SUNNY 67/96

Need Appropriate Solutions!

- Visualization
- Interaction

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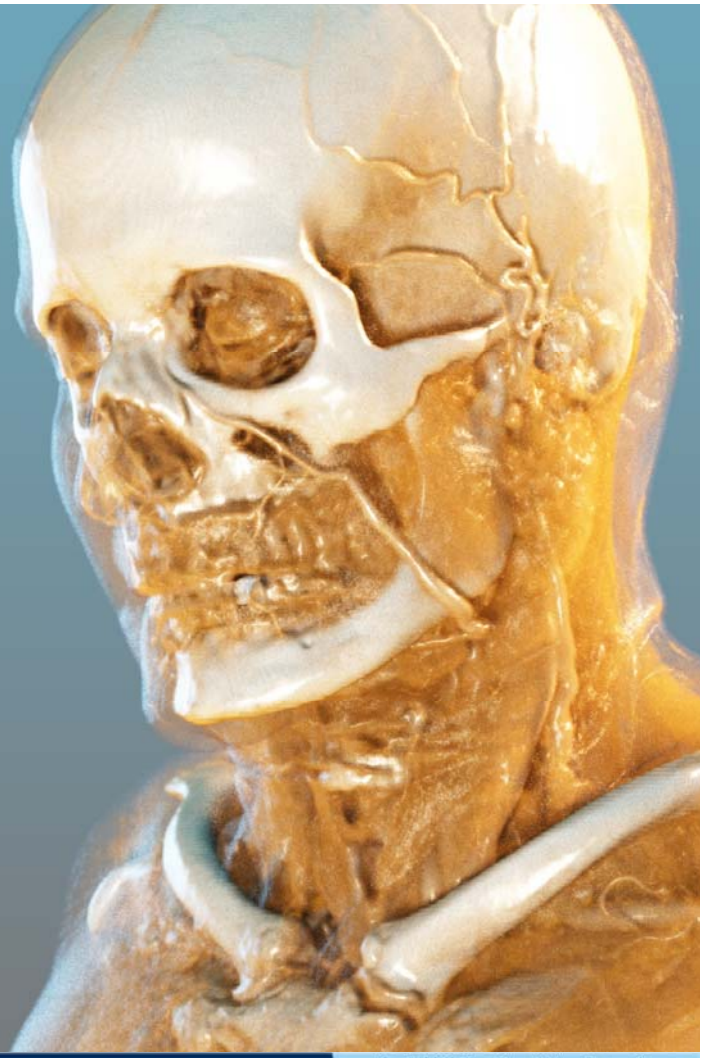
Large-Scale Medical Scans

- Voxel Representations
- 2048^3 resolution (and more)
- Data exceeds working memory by far



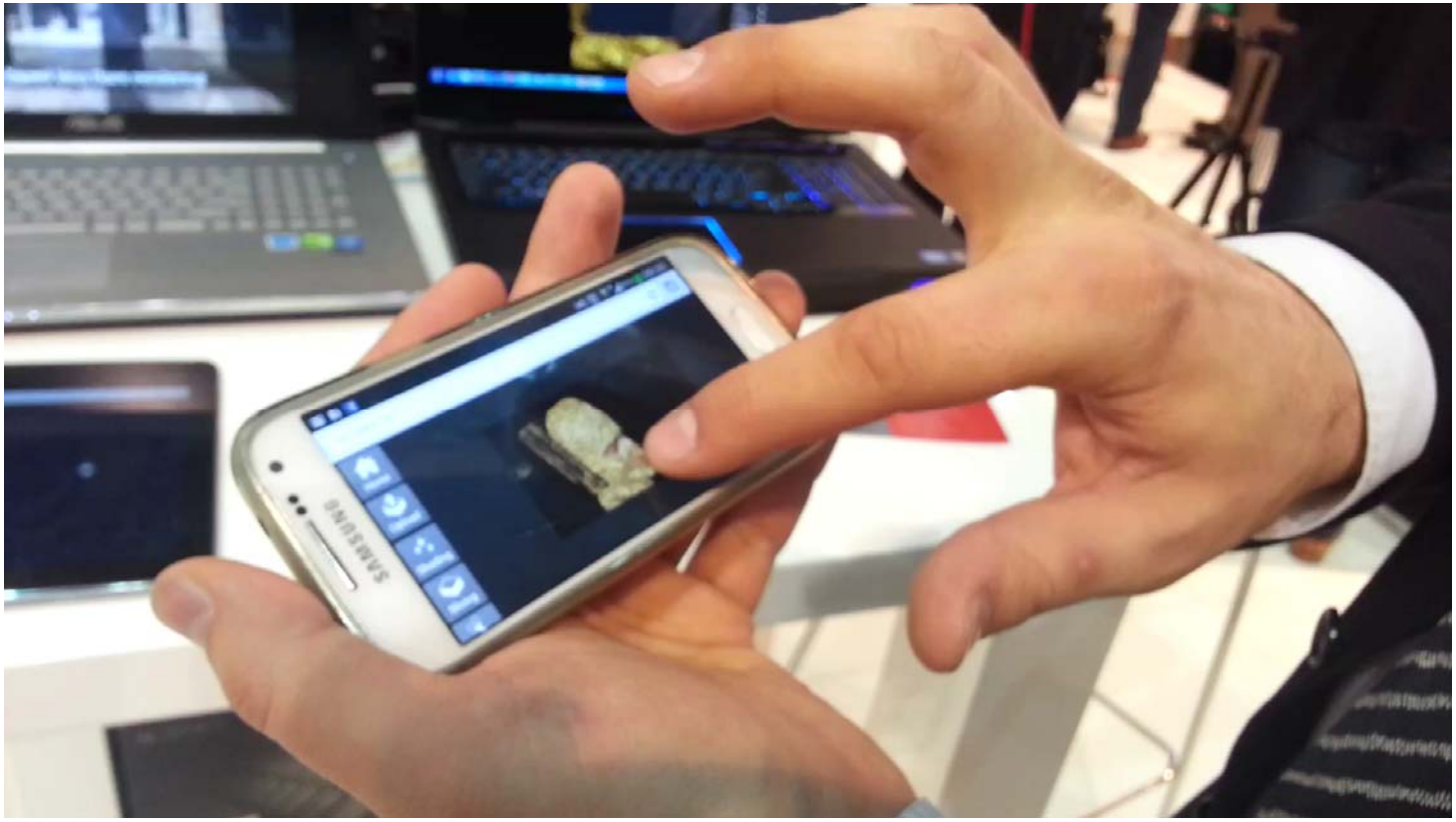
[Dado, Kol, Thiery, Bauszat, Eisemann – Eurographics 2016]

2^51 voxels = 2,251,799,813,685,248 Voxels

Colored DAGs

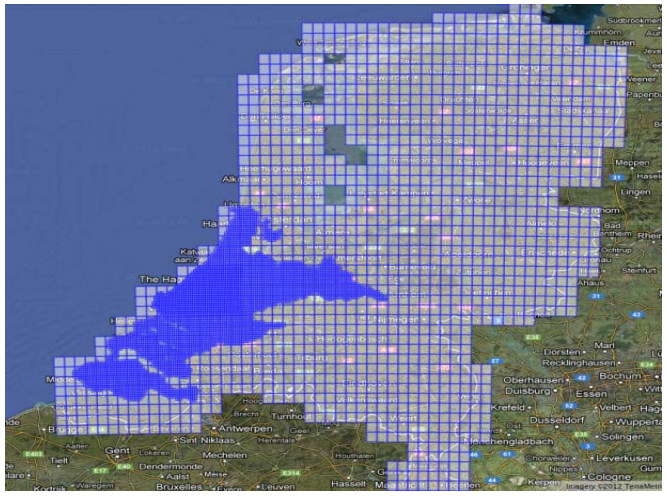
[Pąjak, Herzog, Mantiuk, Didyk, Eisemann, Myszkowski, Seidel – EG2014]

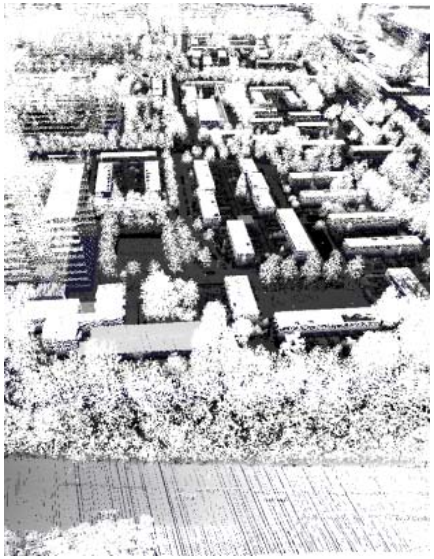
Distributed Computing



Large-Scale Scanned Data Sets

- AHN2/3 dataset with satellite imagery





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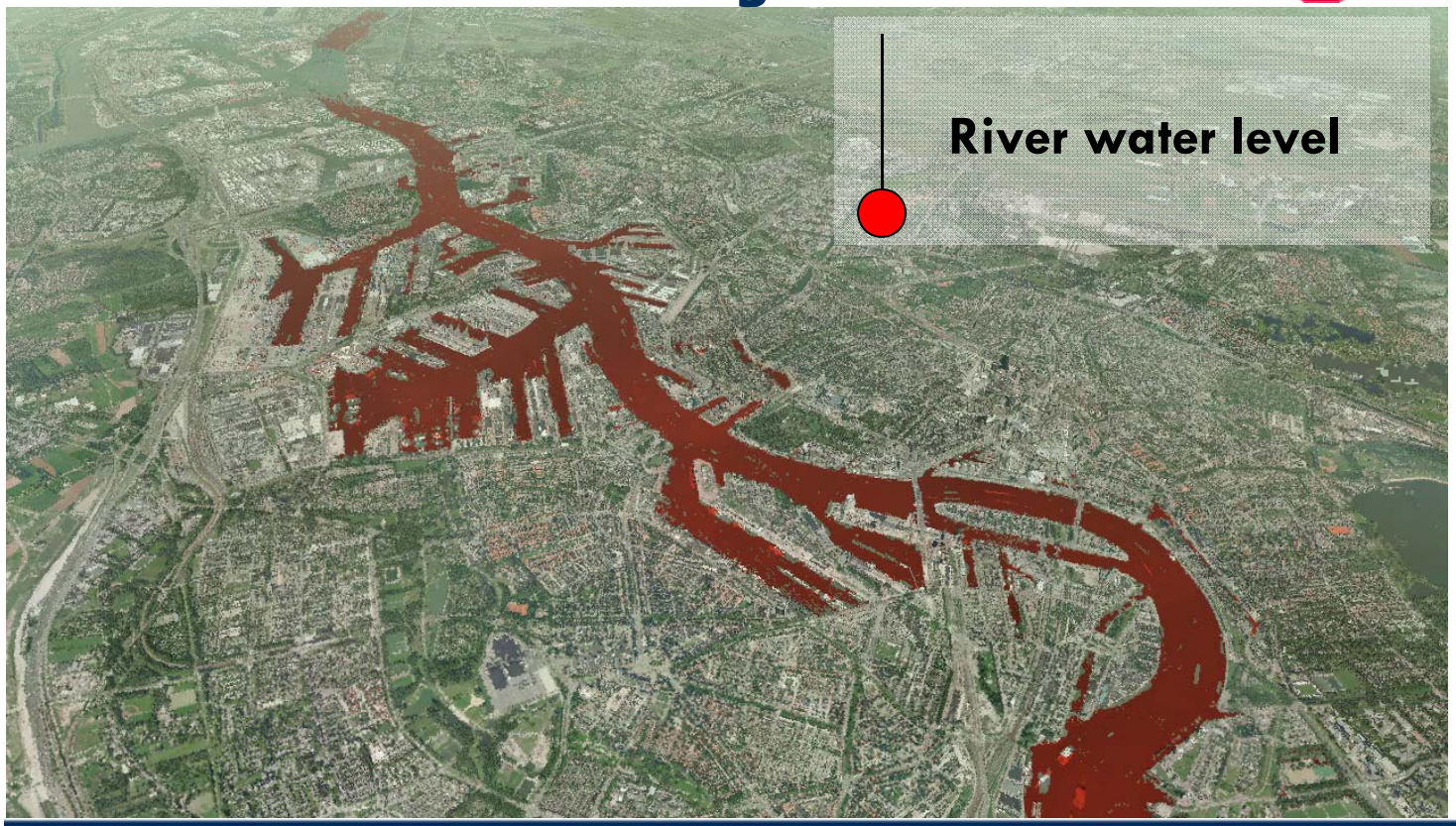
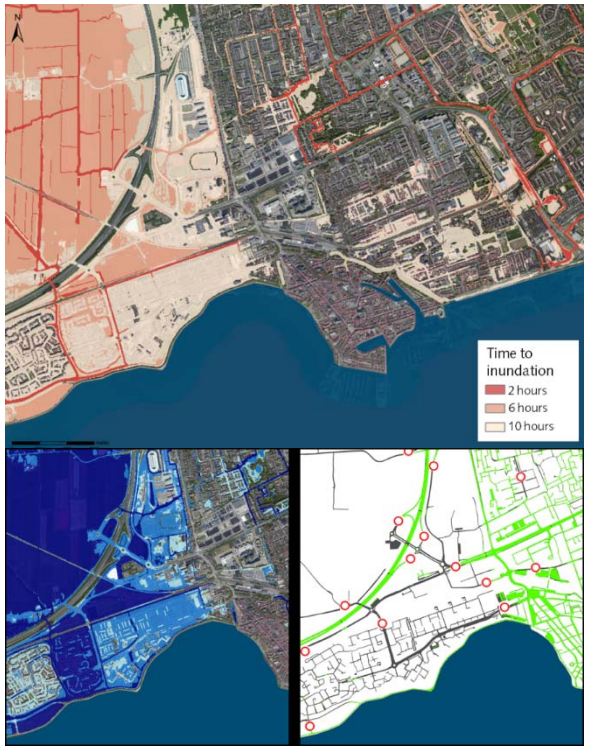
Interaction: Flooding Scenario



[Leskens, Kehl, Tutenel, de Haan, Stelling, Eisemann –
Mitigation and Adaptation/Science for Policy Management 2015]

Interaction: Evaluation of Evacuation Scenarios



- High benefit of realistic visualizations
  > more and more equal discussion between parties

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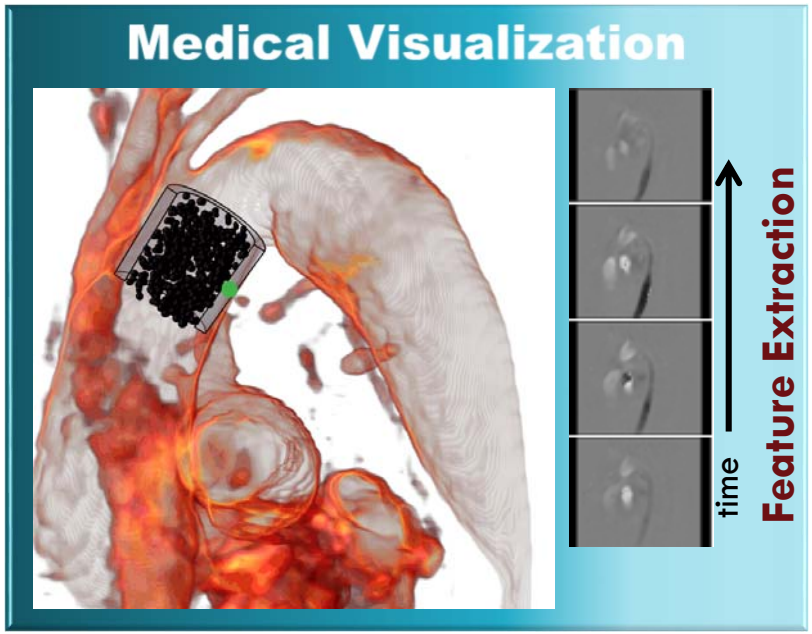
Interaction: Blood Flow Examination



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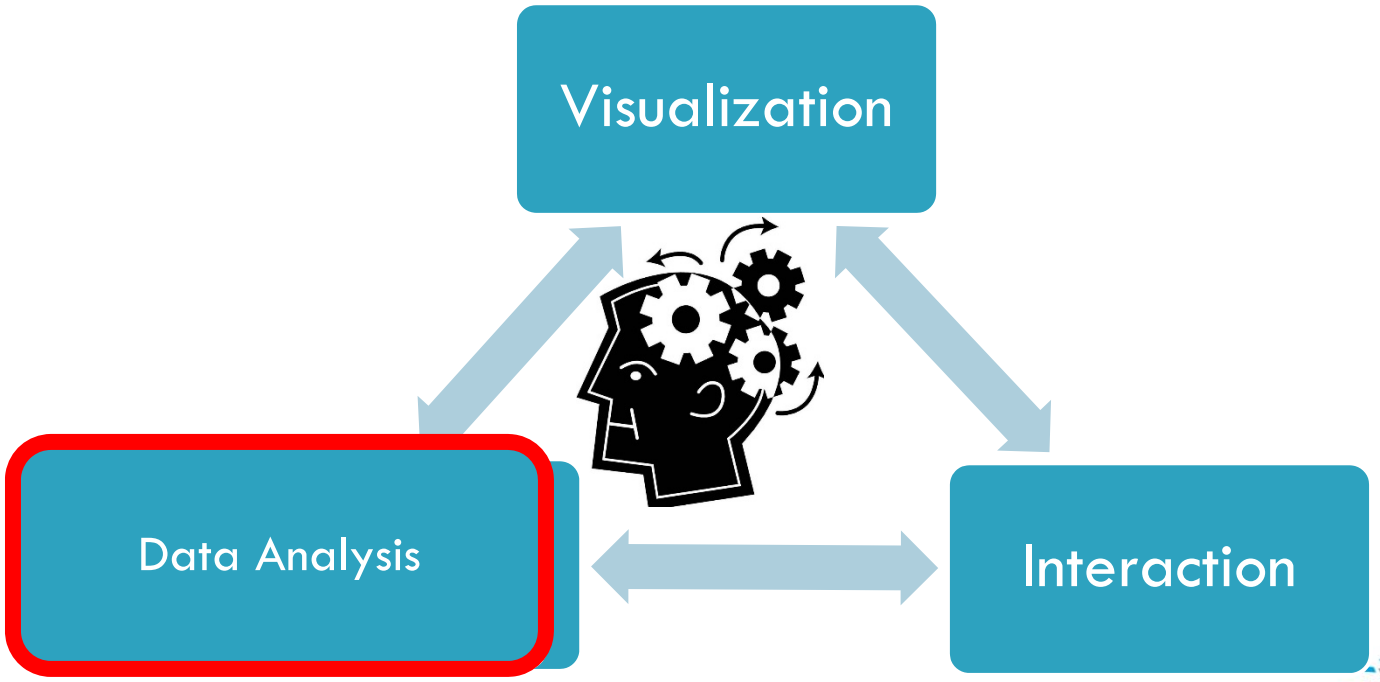
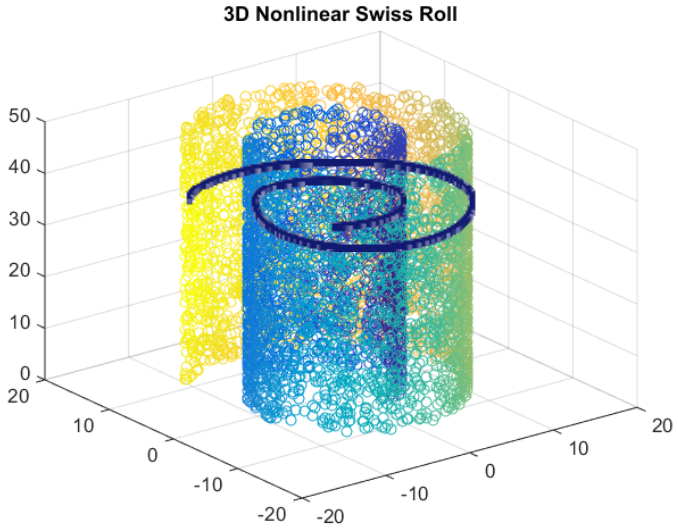
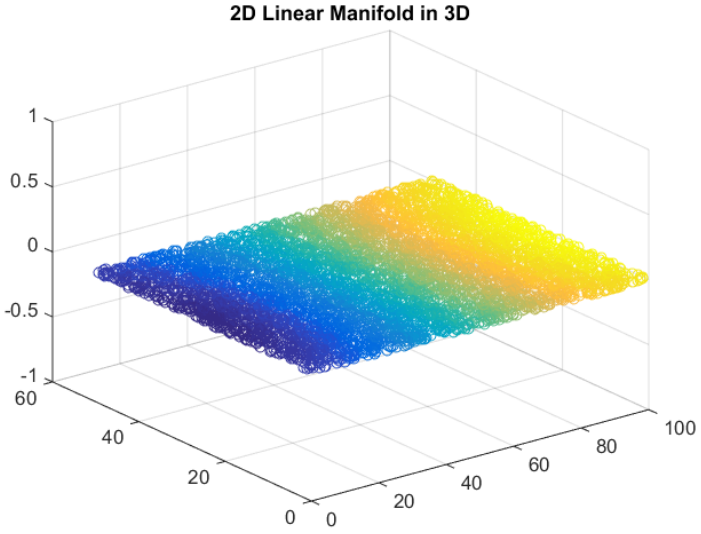
Data Visualizations - Visual Analytics



High-Dimensional Spaces

- A high dimensional space does not imply high dimensionality





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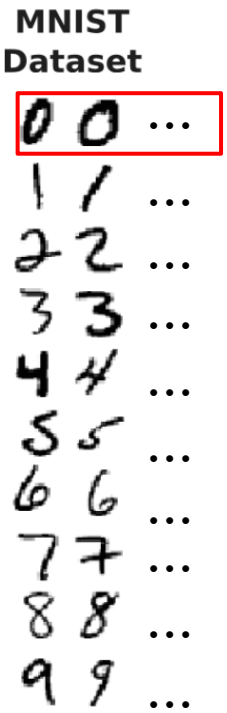
Example: Dimensionality Reduction

t-SNE:

100K samples
with 4096 dim.



100K samples
embedded in 2D

T-SNE: Van der Maaten and Hinton – Journal of Machine Learning 2008

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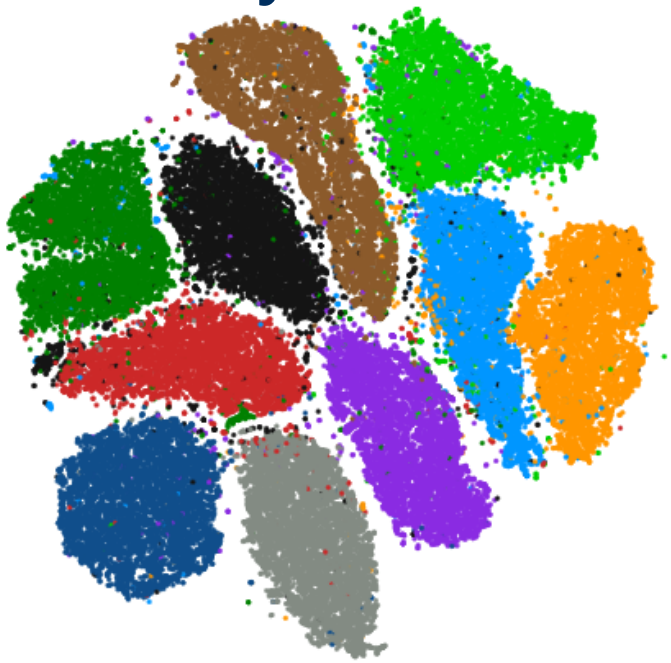
[Pezzotti, Leliveldt, van der Maaten, Hoelt, Eisemann, Vilanova – TVCG2016]

Extreme Acceleration for Data Analysis

tSNE
Time: 3191.8 s

Speed up: 100x



A-tSNE
Time: 30.1 s

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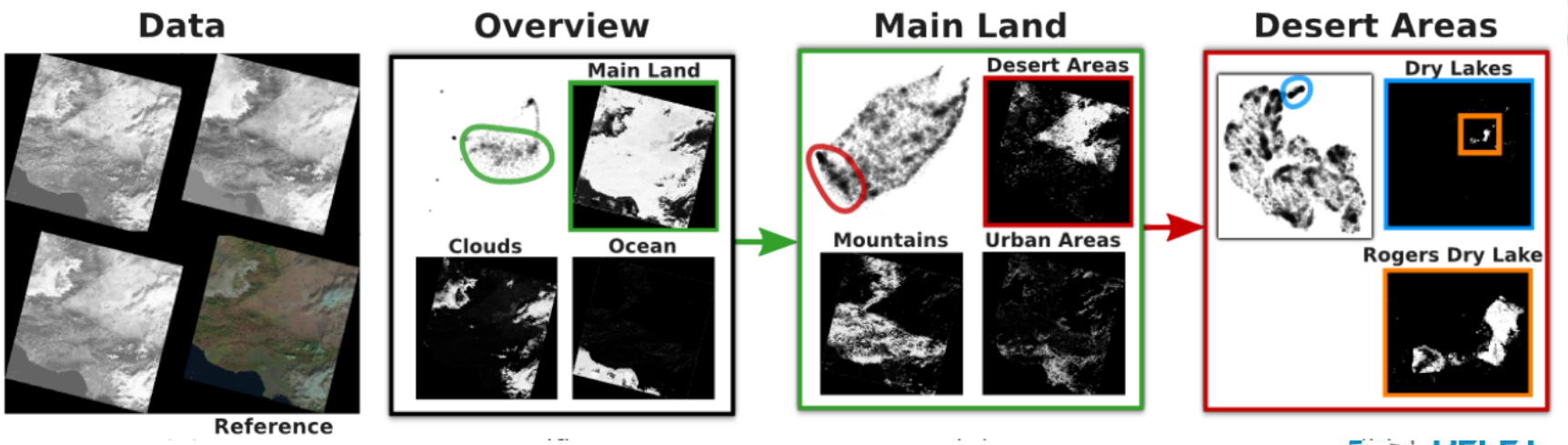
[Pezzotti, Hoelt, Leliveldt, Eisemann, Vilanova – EuroVis 2016]

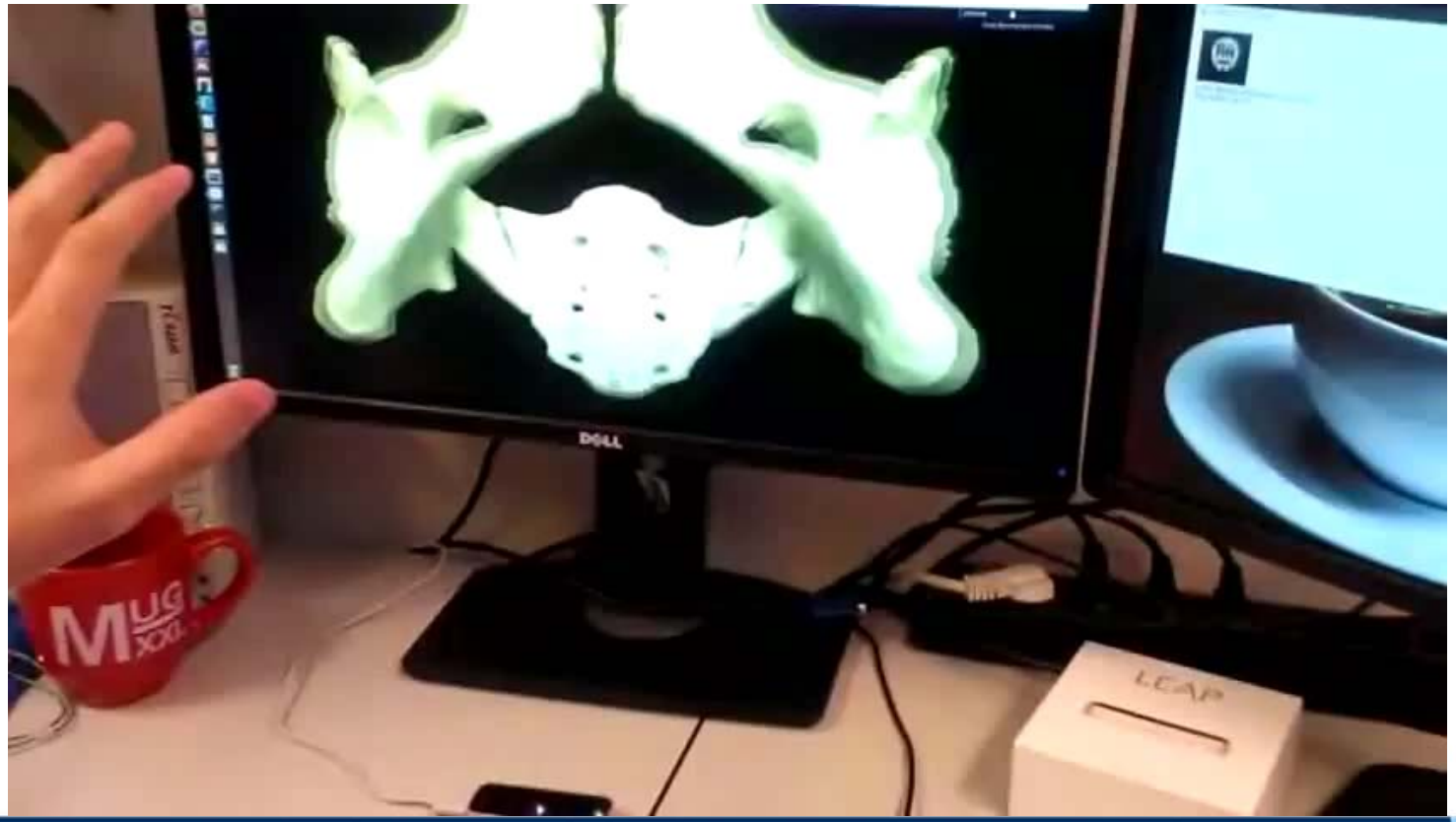
[Pezzotti, Leliveldt, van der Maaten, Hoelt, Eisemann, Vilanova – TVCG 2016]

Hierarchical Dimensionality Reduction

- Organize Data at Different Scales with Support for User Control



New Interaction Methods



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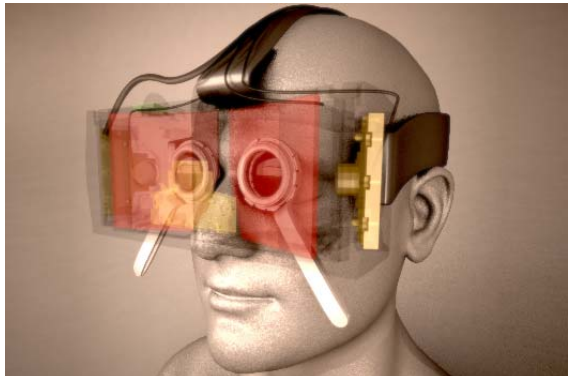
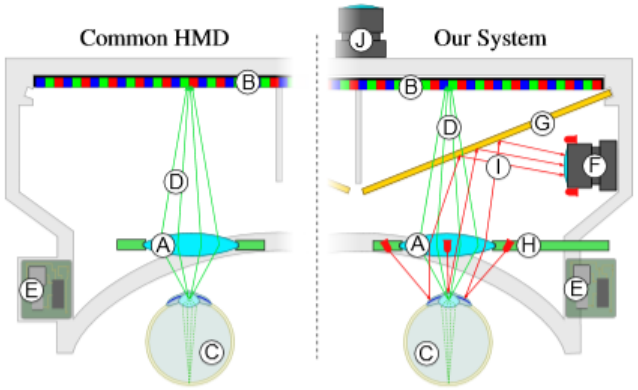
[Stengel, Grogorick, Eisemann, Eisemann, Magnor – ACM Multimedia15]
[Didyk, Ritschel, Eisemann, Myszkowski, Seidel – SIGGRAPH11]

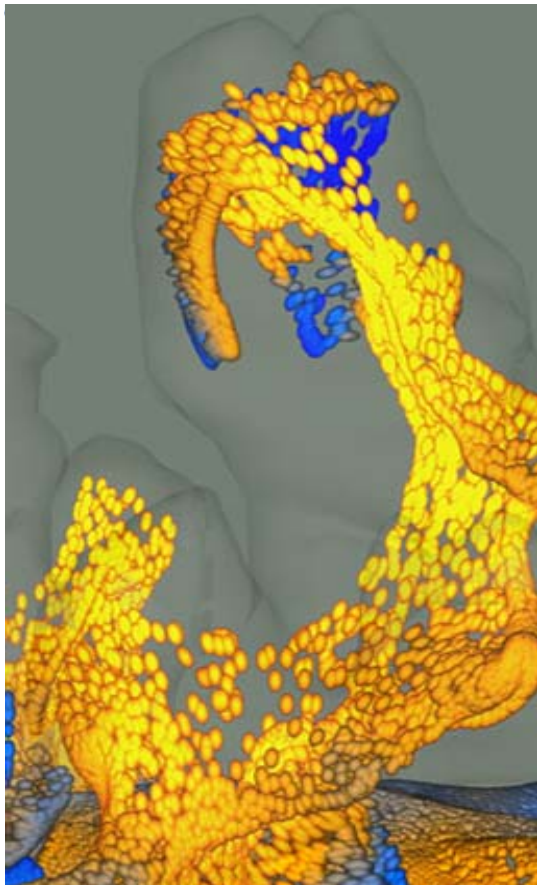
New Display Technology: Perception, Stereo, and Virtual Reality





Data Science in **Computer Graphics and Visualization** at TU Delft

- **Data Generation**
  - Modeling
  - Reconstruction
  - Simplification
  - Animation
- **Data Display**
  - Large-Scale (Realistic) Rendering
  - Illustrative Rendering
  - Perceptual Methods
  - Novel Display Devices (VR, AR, multiview…)
- **Data Visualization & Interaction**
  - Domain Specific Visualization (Medical, Geoscience,…)
  - Visual Analytics
  - Interaction Methods



Prof. dr. Elmar Eisemann
Computer Graphics & Visualization
http://graphics.tudelft.nl

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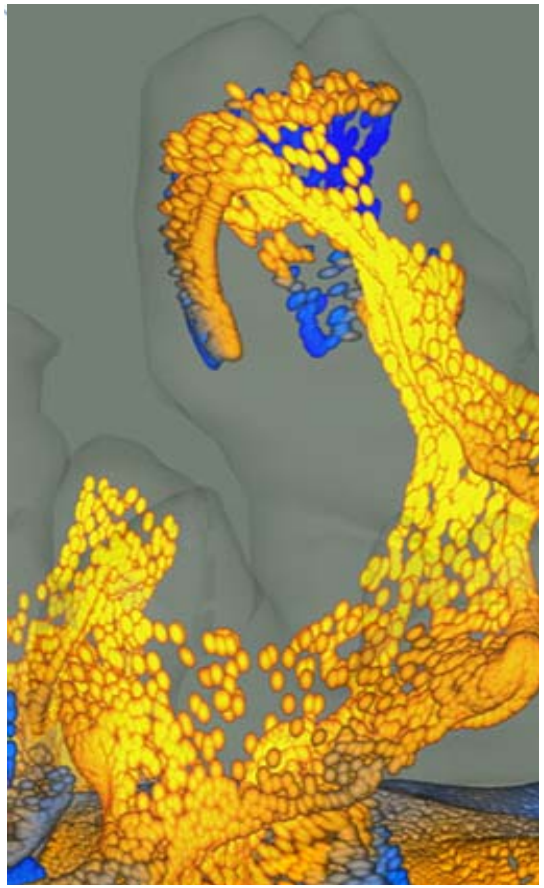

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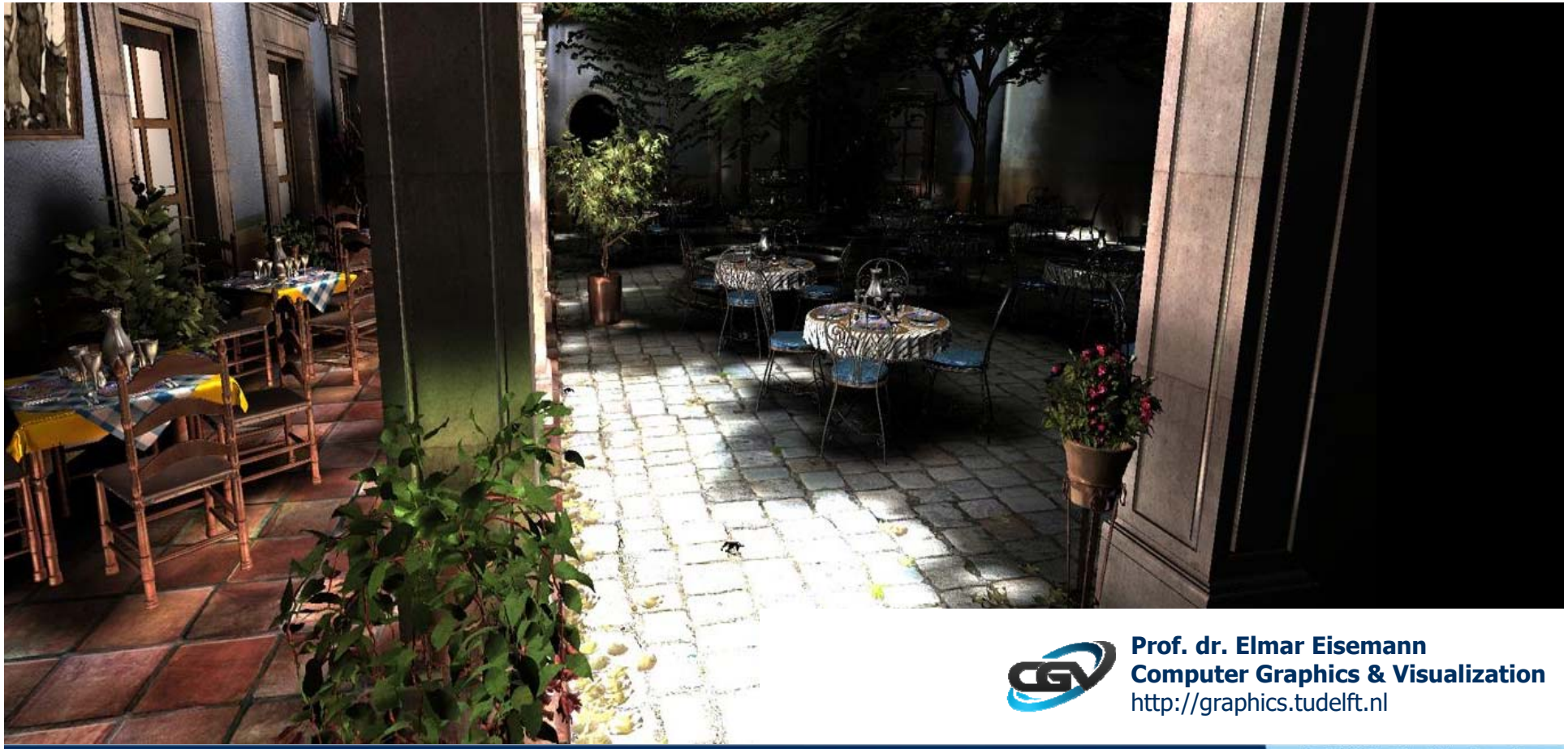
Thank you very much!



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10 November 2016

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