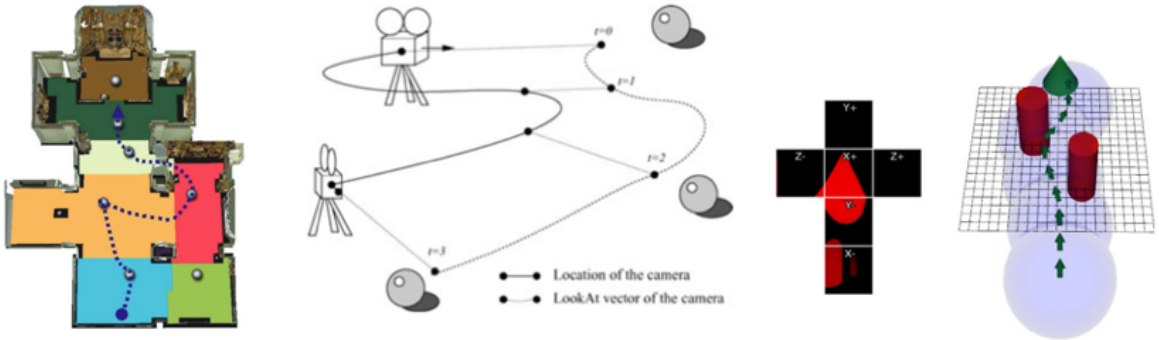
1. Smart Camera Control

- Research and summarize methods used for (semi-)automated camera control in interactive applications
- Methods which can be applied in scientific visualization and leverage specific data characteristics in a “smart” way are to be preferred



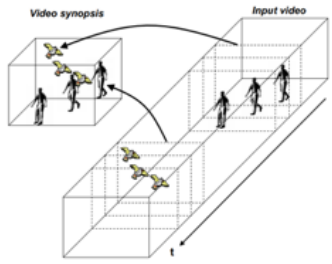
David Kouřil

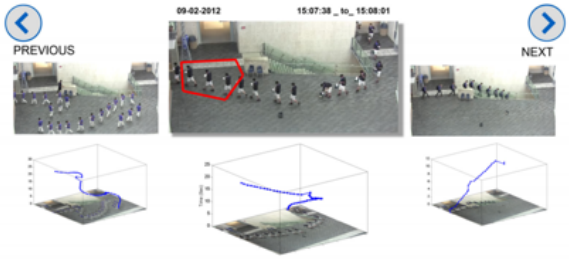
2

The goal of this topic is to provide an overview of camera control navigation methods which either assist with, or even completely strip the user of the responsibility of, controlling the camera when exploring a 3D scene. These methods usually take advantage of the specific characteristics of the scene they deal with: by having some general knowledge about the scene, we can design a method that automates the navigation in the space to a certain extent.

2. Summarizing and Exploring Extremely Long Videos

- Investigate methods for gaining information from extremely long video footage, e.g., from surveillance cameras
- Focus on methods that either summarize the interesting actions captured or enable less cumbersome exploration (playback) of these media





David Kouřil

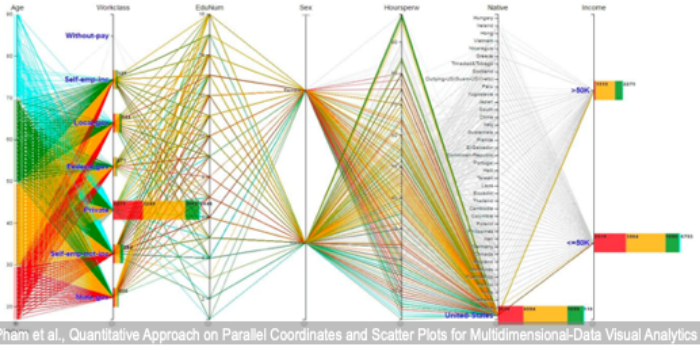
2

In this topic you will investigate ways how to gain information from a very long video footage. The topic can either go in the direction of video summarization---i.e., interesting events happening throughout the hours if not days are condensed into a representation that takes significantly shorter time to consume---or supporting exploration---where the user is given tools for quickly navigating through all the time steps, with additional semantic information about the events throughout the video.

The goal is to write a state of the art report in which you will present available solutions to these tasks.

3. Comparative Visualization of High Dimensional Data

Scientists as well as practitioners often need to compare multiple datasets, for example results of feature characteristic derived from segmented images or nD data from simulation. Current strategies typically focus on **dimensionality reduction techniques** (e.g., PCA, MDS, t-SNE), computing **similarity metrics** (e.g., Euler distance in nD) or **comparing individual characteristics** with each other using conventional visualization techniques (e.g., scatter plots, parallel coordinate plots). Your task is to provide an overview over the state-of-art in **methods for comparing multiple high dimensional datasets**.



Source: Pham et al., Quantitative Approach on Parallel Coordinates and Scatter Plots for Multidimensional-Data Visual Analytics

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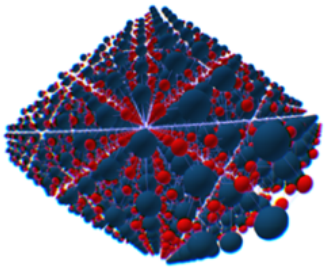
4. Visualization Techniques for AR/VR Applications in Material Science

Virtual and augmented reality has come to stay and is used in many application domains. AR and VR feature the potential to boost data analysis through more intuitive insights and more intuitive interactions; the transfer of the spatiality is intuitive and probably more effective than when rendering the same scene on a 2D monitor. Virtual and augmented reality have the potential to help in a variety of tasks such as quality control / parts inspection, the characterization of the micro-structure of materials, or the visualization of atomic structures. Your task is to provide an overview on the state of the art regarding **methods in virtual and augmented reality:** where these be used to support material science tasks, what are their benefit, what are their limitations.



García-Hernández and Kranzlmüller: NOMAD VR: multiplatform virtual reality viewer for chemistry simulations

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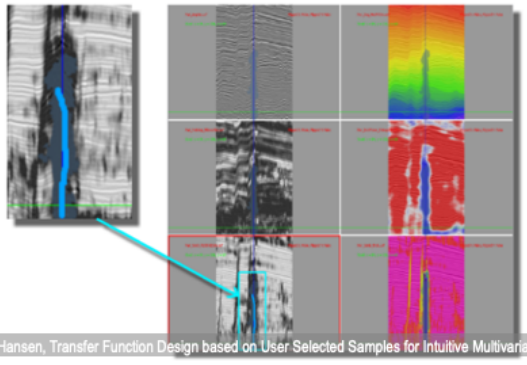
5. Guidance Methods for Transfer Function Specification

When directly visualizing (potentially multi-variate) volume datasets, a transfer function is required. Current tools for this purpose are often unintuitive; its often not clear how changes in the transfer function will affect the resulting visualization; using volume visualization tools therefore first requires a certain experience by the user, as well as often a trial and error approach to color the volume in the desired fashion. Recently, methods have emerged that simplify this process, or provide guidance to the user. Your task is to provide a survey on the state of the art of **methods guiding users in setting up transfer functions** for volume visualization.



Source: Zhou and Hansen, Transfer Function Design based on User Selected Samples for Intuitive Multivariate Volume Exploration

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6. Visualization of Bipartite / k-Partite Graphs

- Graph with vertices divided into two independent sets, such as
  - People and affiliations, genes and conditions, actors and movies
- Which visualization techniques exist?
- How to explore a k-partite graph interactively?

[Sun et al., BiSet, TVCG 2016]

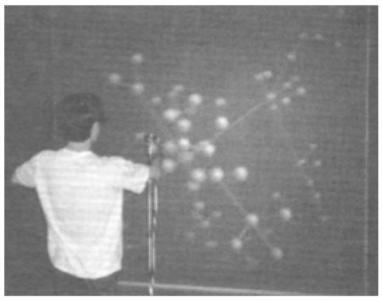
[Streit et al., Furby, BMC Bioinformatics 2014]

Manuela Waldner 26

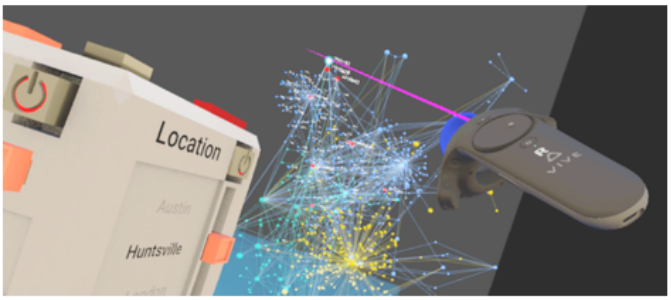
Bipartite or k-partite graphs are a special class of graphs whose nodes are divided into two or k sets. These sets are independent, which means that there are no edges connecting nodes of the same set. K-partite graphs are ubiquitous and can be found in social networks, where nodes can be persons which are associated with projects, or in biology, where nodes can be genes and conditions, and edges describe the expression of genes under these conditions. There are different ways how to visualize k-partite graphs, including linked lists, node-link diagrams, and matrix views. This report should describe existing visualization techniques, as well as interaction techniques to explore bipartite graphs.

7. Visualization of Networks in Virtual Reality

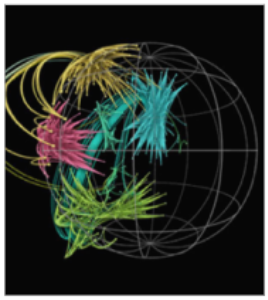
- Immersive analysis of 3D graphs in virtual reality from the 90ies to now:
  - Rendering & graph layout
  - Embodied interaction & effective locomotion



[Osawa et al., 2000]



[Drogemuller et al., 2017]



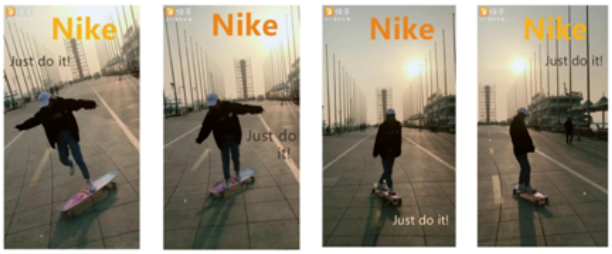
[Kwon et al., 2016]

Manuela Waldner 27

There is a lot of scientific evidence that immersive 3D visualization of graphs helps users to detect patterns in complex networks. Graphs have been visualized in virtual and augmented reality already for decades. Nowadays mature and affordable VR hardware makes immersive analytics attractive for a very wide range of users. In this survey, the history and state-of-the-art of network visualization in VR should be summarized. The report should provide an overview of the employed graph rendering and layout techniques, interaction techniques, and ways how to navigate around and within a network.

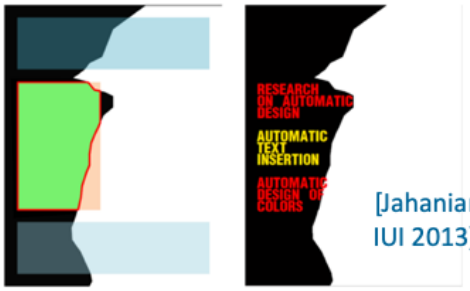
8. Automatic Layout Generation

- Layout algorithms for computational composition of many media (text, images, etc.) into a single:
  - Magazine cover
  - Advertisement or banner
  - Poster …



[Liang et al., BigMM 2018]

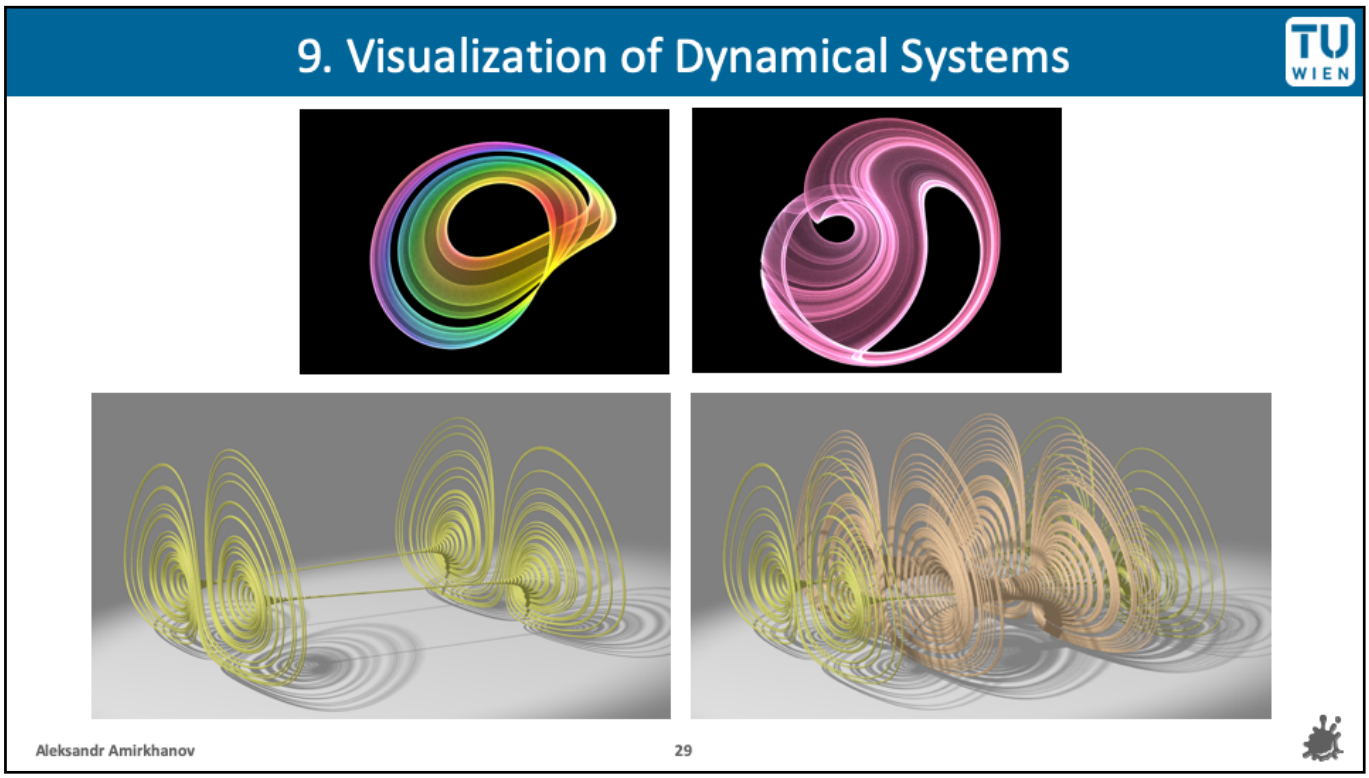
[Yin et al., MM 2013]



[Jahanian et al., IUI 2013]

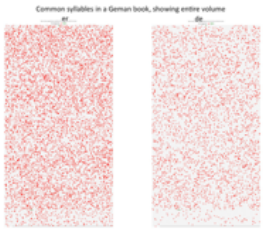
Manuela Waldner 28

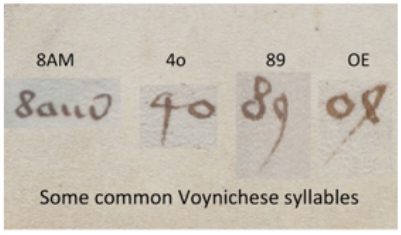
Magazine covers, advertisement banners, or posters should be aesthetic, but also very effective in conveying a message. They are usually created by skilled artists from a set of possible input data, such as images and text snippets. In this survey, layout algorithms that automatically generate single compositions from multiple image and text input material should be collected and compared.



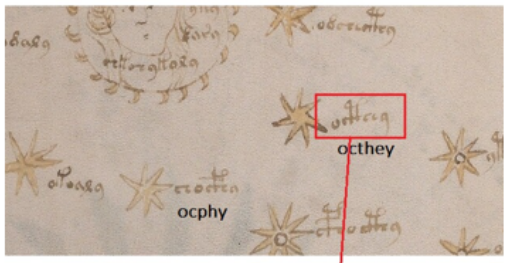
Dynamical system are used to model various system that evolve in time. These systems are often multi-dimensional and can be formulated as ordinary differential equations. In this topic, the student has to research various visualization techniques used to visualize this systems.

10. Visualization of Text in Voynich Manuscript





Folio 68



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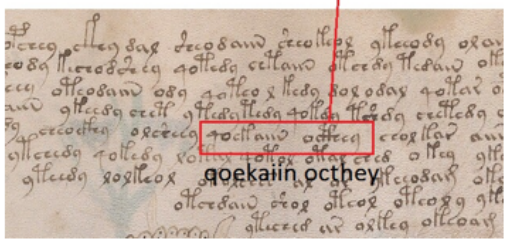
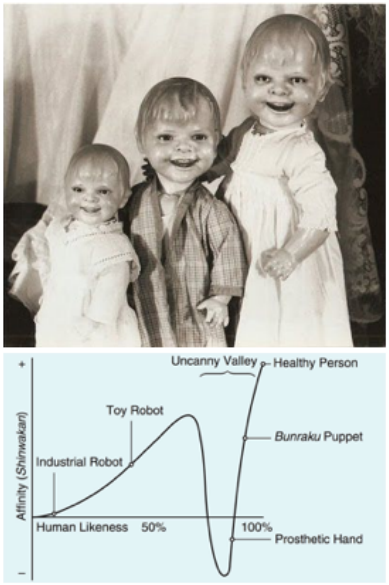


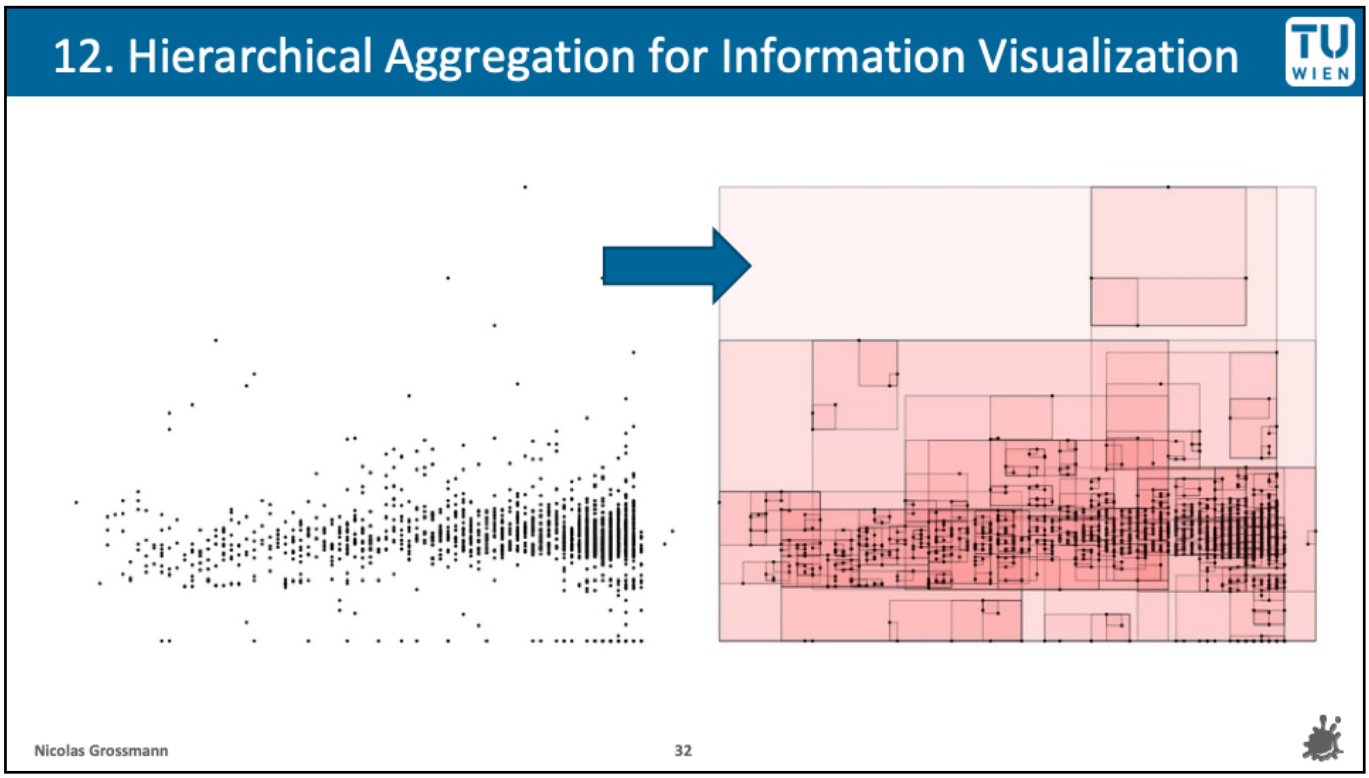
Aleksandr Amirkhanov 30

The Voinich Manyscript is considered to be one of the most mysterious manuscript in the world as it is written in an unknown language its content has not been decoded yet. The manuscript was discovered in 1912, and since then many scientists from different areas did an enormous number of unsuccessful attempts to decode the content. In this topic, the student has to research which visualization were employed to support the domain scientists and what was their purpose.

11. Visualization and Uncanny Valley

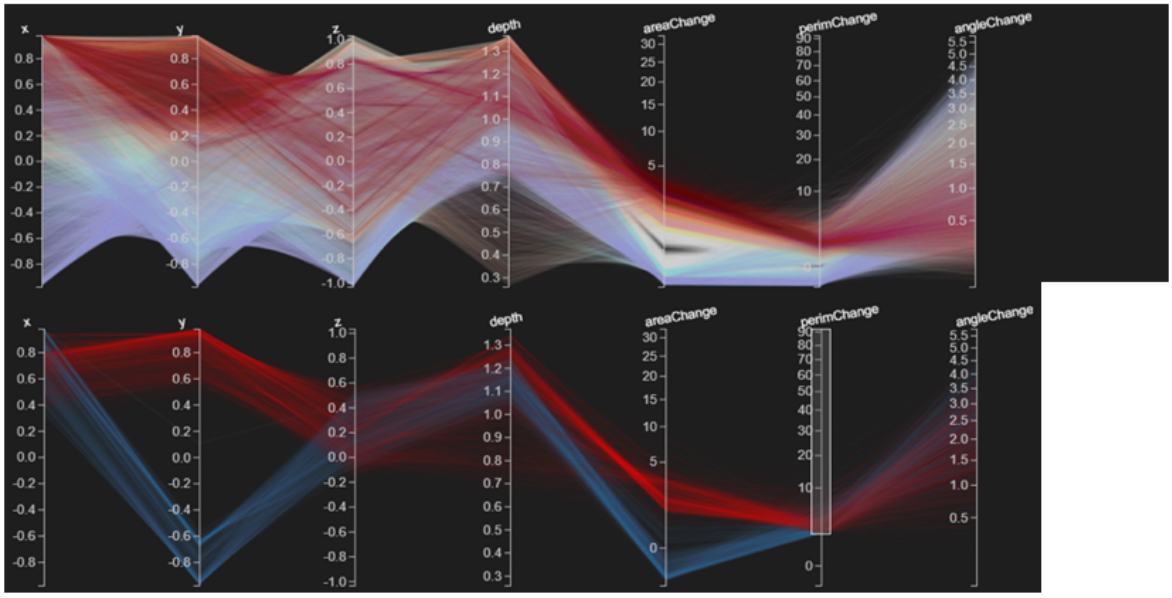


With the development of renderings techniques the problem of uncanny valley is arising more often. This might be an issue when a visualization concerts previewing an outcome of a medical treatment, for example, plastic surgery or dental treatment. In this topic, the possible ways to avoid the uncanny valley must be explored.

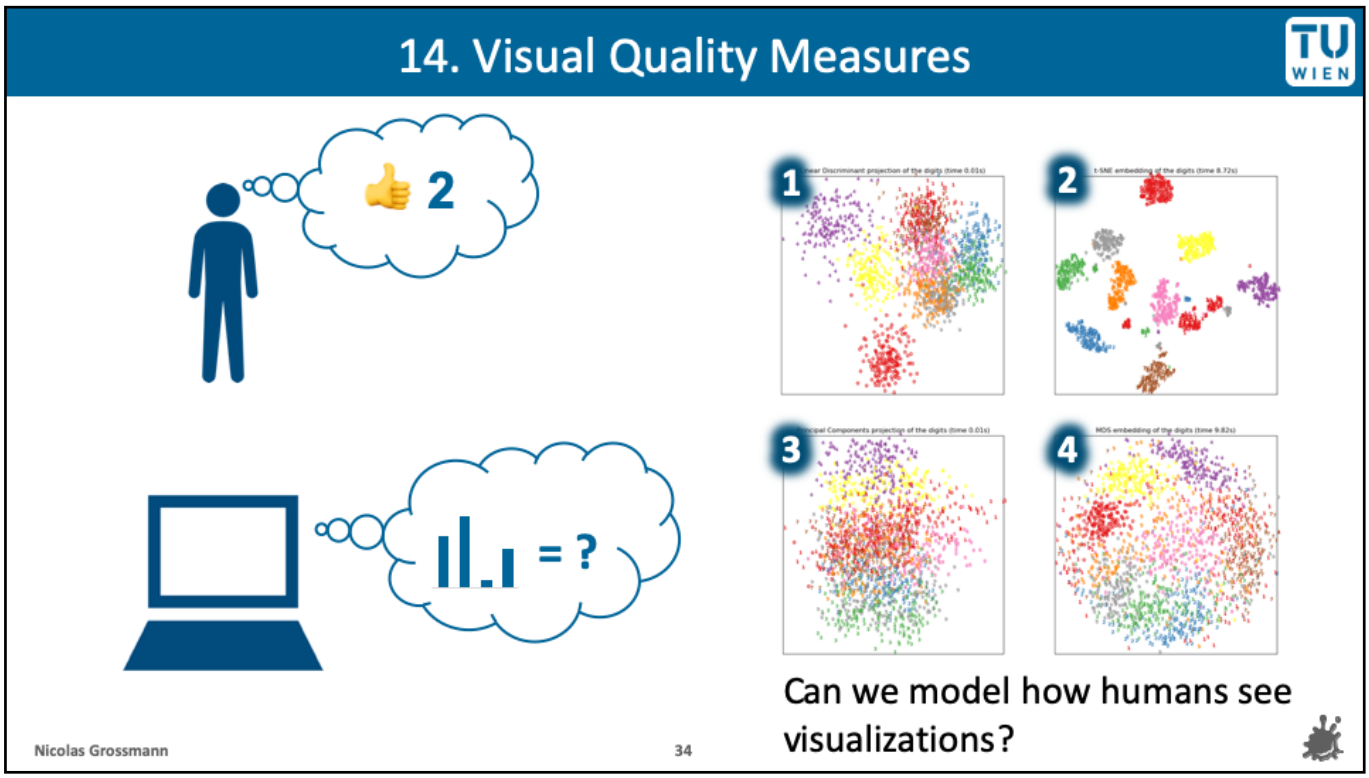


Many visualization approaches work well on small datasets but struggle to extend to larger ones, where it gets harder to provide an overview of the data as well as allowing users to inspect all details. One way to tackle this problem is hierarchical aggregation, which combines elements step-by-step until a more manageable number of elements is visualized. In this work student should research current practices in hierarchical aggregation with a focus on information visualization techniques like scatter plots or node-link diagrams.

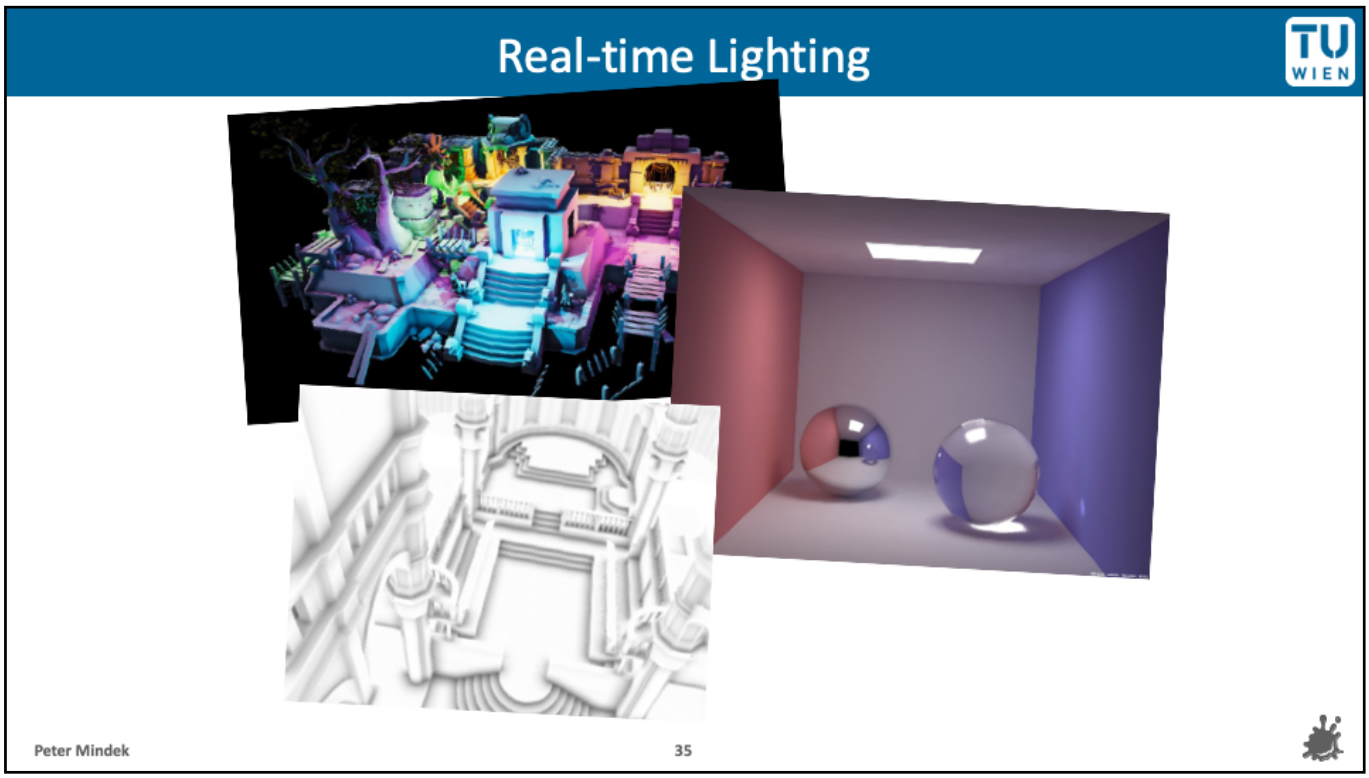
13. Parallel Coordinates



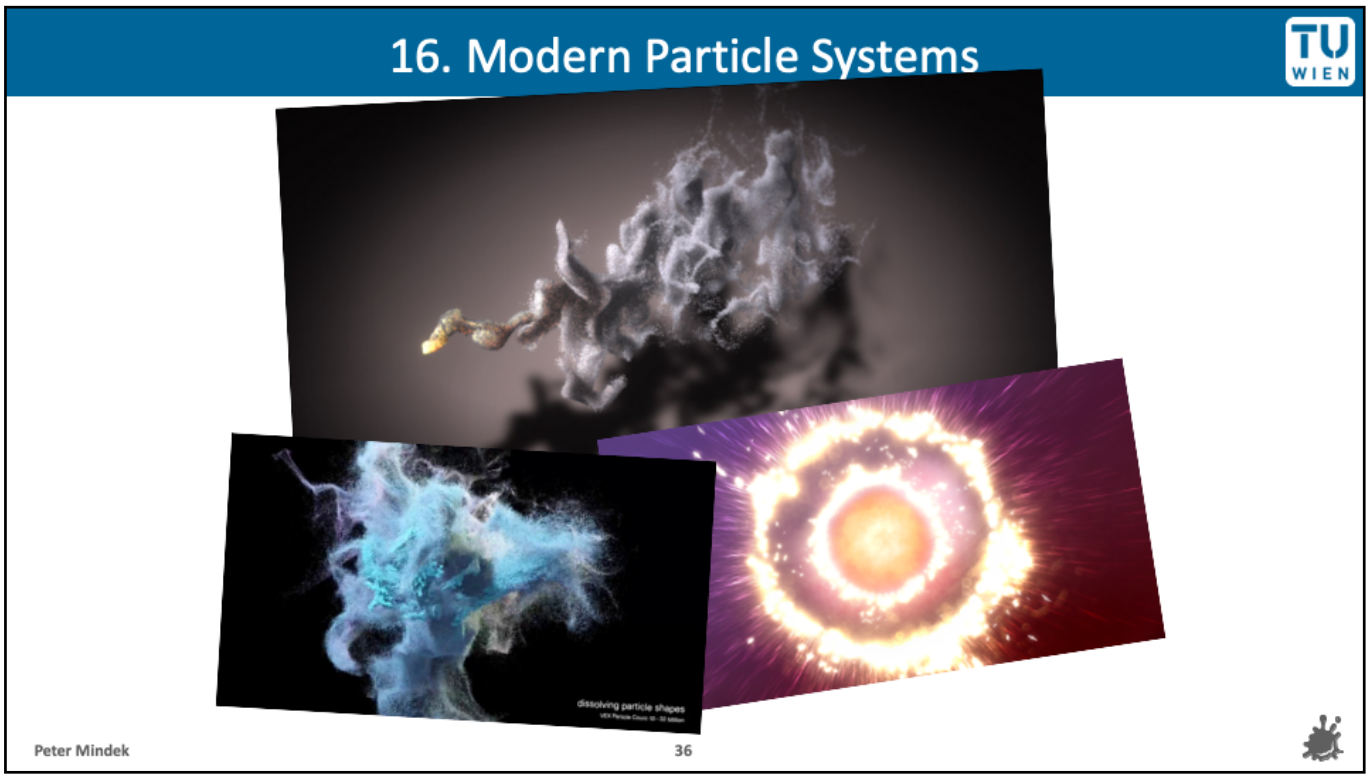
Parallel Coordinates are a common technique to visualize multi-dimensional data and have been applied to a large range of usage scenarios. However, they are difficult to comprehend for new users. In this report, recent advances on this topic should be analyzed especially considering approaches that make them more interpretable and provide better insights into the data. In this regard, the use of color and blending should be discussed.



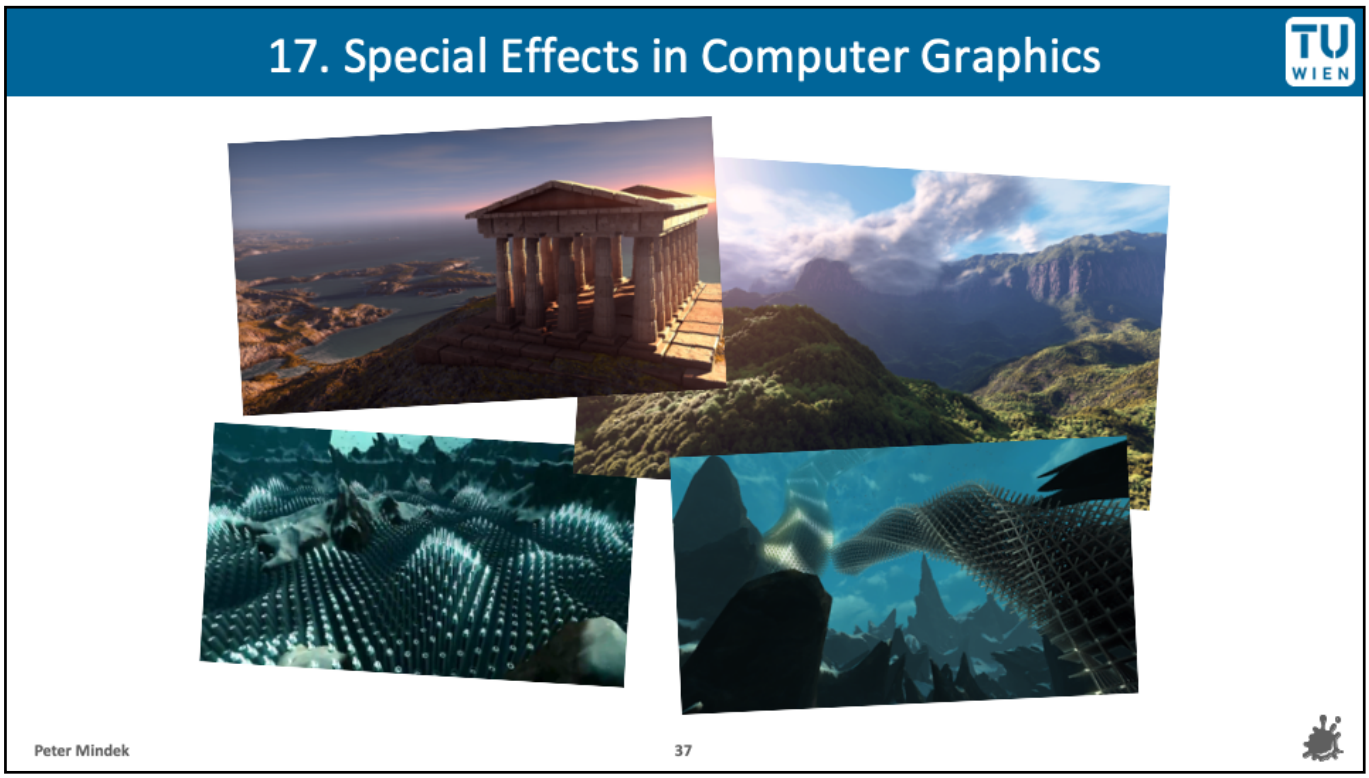
Visual quality measures seek to model the human's innate perception of visual properties, in the shown example the important visual property is the cluster separatability between the different groups. Most probably human would indicate that plot number 2 ideally separates the clusters, the question is how could a machine also detect this. Knowing the ideal perceptual configuration automatically would allow us to guide users in the creation of good visualizations. For this topic, the student needs to research current approaches to measure and model visual perception in visualization.



This topic covers real-time lighting algorithms approximating global illumination. From simple screen-space effects such as screen-space ambient occlusion (SSAO) and screen space directional occlusion (SSDO), to more advanced algorithms combining path-tracing with machine learning denoising should be reviewed.



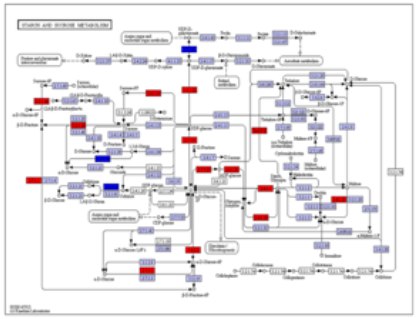
Particle systems are used in today's movies and videogames to create large variety of effects. Current GPUs allow the particle systems to handle tens of millions of particles in real time, which can be exploited to create interesting visuals. In this topic, you will explore the inner workings data structures, and acceleration algorithms of the contemporary particle systems.

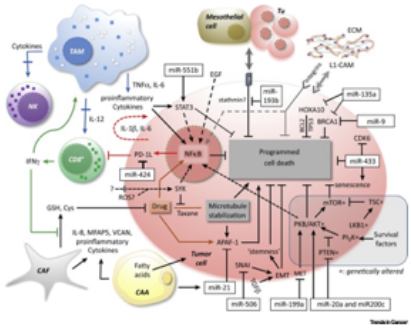


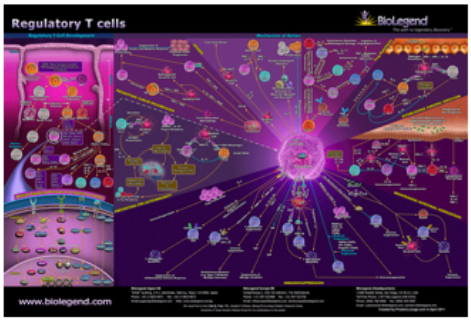
This topic investigate various special effects in computer graphics.

18. Network Visualization for Biological Pathways

- **Challenge:**
  - Layout simplification and arrangement
  - Scalability, complexity, and usability





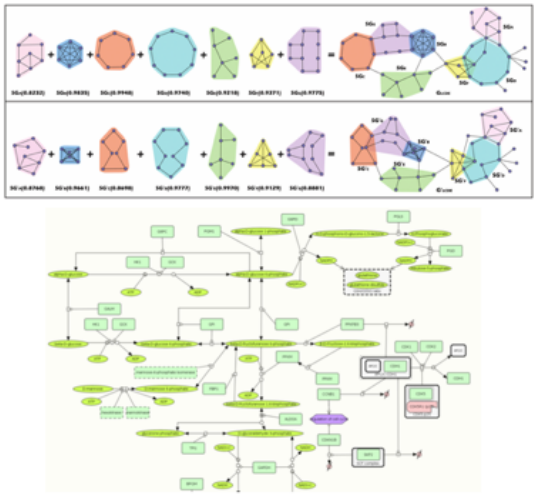


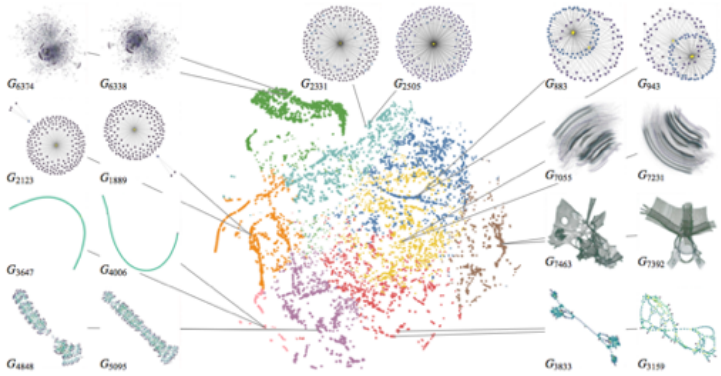
Hsiang-Yun Wu 38

Networks are well-known representations for describing a relationship of entities between data samples. Thus, it is also intuitive to use networks as a base for visually describing biological interactions. In this seminar, network visualization techniques should be categorized and organized as a meaningful taxonomy.

19. Machine Learning in Graph Visualization

- **Challenge:**
  - Formulation for machine learning technique



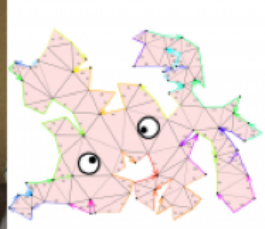


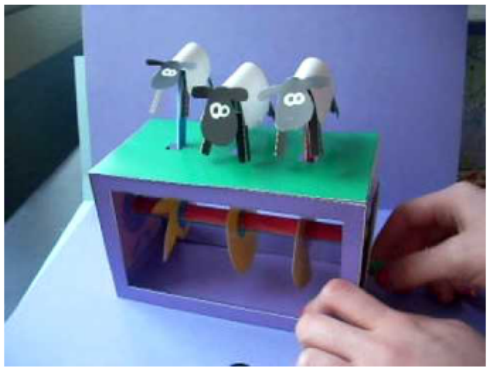
Hsiang-Yun Wu 39

Machine Learning (ML) has been widely used to solve several visualization problems by learning implicit rules from the existing drawings. This topic investigates the conventional ML approaches and tries to clarify the strengths and weaknesses of the current state-of-the-art in graph visualization.

20. Data Physicalization

- **Challenge:**
  - Geometry
  - Combinatorial complexity
  - Optimization

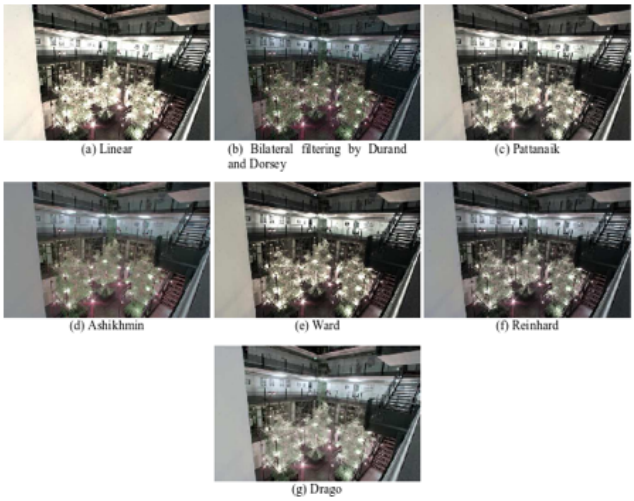




This topic investigates physical models of datasets.

21. HDR tone mapping techniques

- Compress HDR images/renderings to display on LDR screens
- Explain and compare different approaches and methods
  - Global vs. local
  - Perception based
  - Subjective quality



Tone mapping is a technique to compress images or renderings of high dynamic range (HDR) for low dynamic range (LDR) displays. The aim of the work is to explain and compare different tone mapping approaches and common methods. For example, a discussion of global vs. local operators should be included, as well as operators based on the human perception or the subjective quality assessed via user studies.

22. Interaction in Virtual Reality

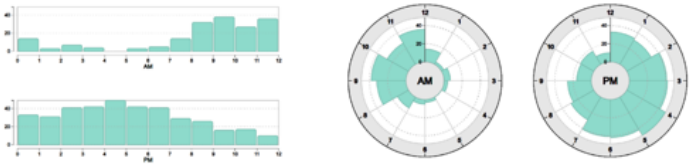
- Mouse and keyboard not suited for VR input
- Evaluate input devices and interaction methods such as
  - Different controllers
  - Eye-tracking interaction
  - Locomotion methods

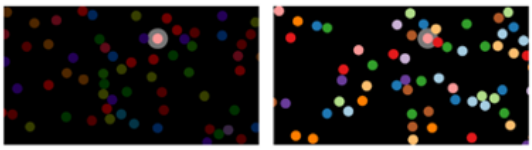
Laura Luidolt 42

For Virtual Reality (VR) applications different interaction methods are necessary than the standard mouse and keyboard input for PCs. The most commonly used input devices are controllers, which already greatly vary in shapes and interaction options. Additionally, more advanced techniques such as eye tracking, finger tracking or locomotion (body movement in VR) should be evaluated.

23. Perception in Visualization

- Better comprehension of visualized data by taking human perception into account
- Explore major influences of perception, e.g.,
  - Color schemes
  - Data representation
  - Attention cues
- … and how they can be used to improve various visualizations





Laura Luidolt 43

Human perception is flawed and limited. In order to present data in a comprehensible way, we need to be aware of these factors. A basic overview of the human visual system should be given and the major influences in perception have to be explored. For example, the representation techniques for spatial or temporal data can be evaluated or how various attention cues can guide a user's notice through large data sets.