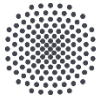


University of Stuttgart
Visualization Research Center (VISUS)

Immersive Analytics: Augmented Reality Meets Visualization

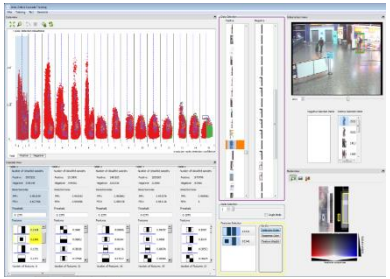
Daniel Weiskopf

Background

- Visualization Research Center
  Visualisierungsinstitut der Universität Stuttgart (VISUS)
- 3 research groups: Ertl, Sedlmair, Weiskopf
- Basic research in visual computing
- Interdisciplinary projects and applications

Image © D. Weiskopf

Overview



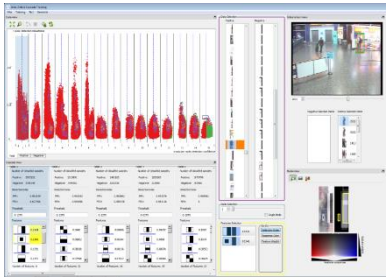
Visual analytics

+

Immersion
(AR/VR)

= Immersive analytics

Overview



Visual analytics

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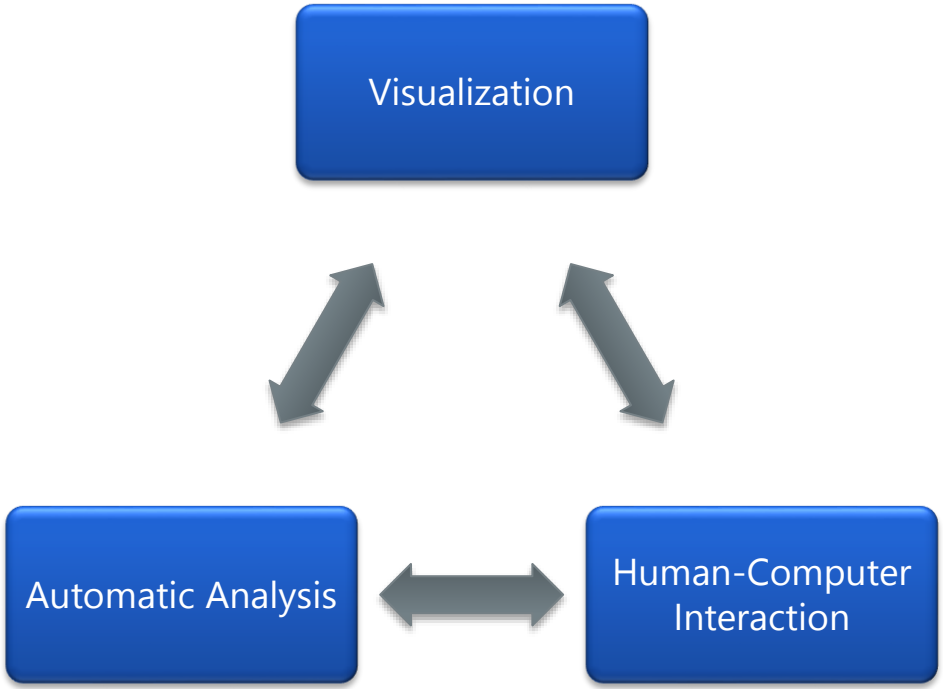
Visual Analytics

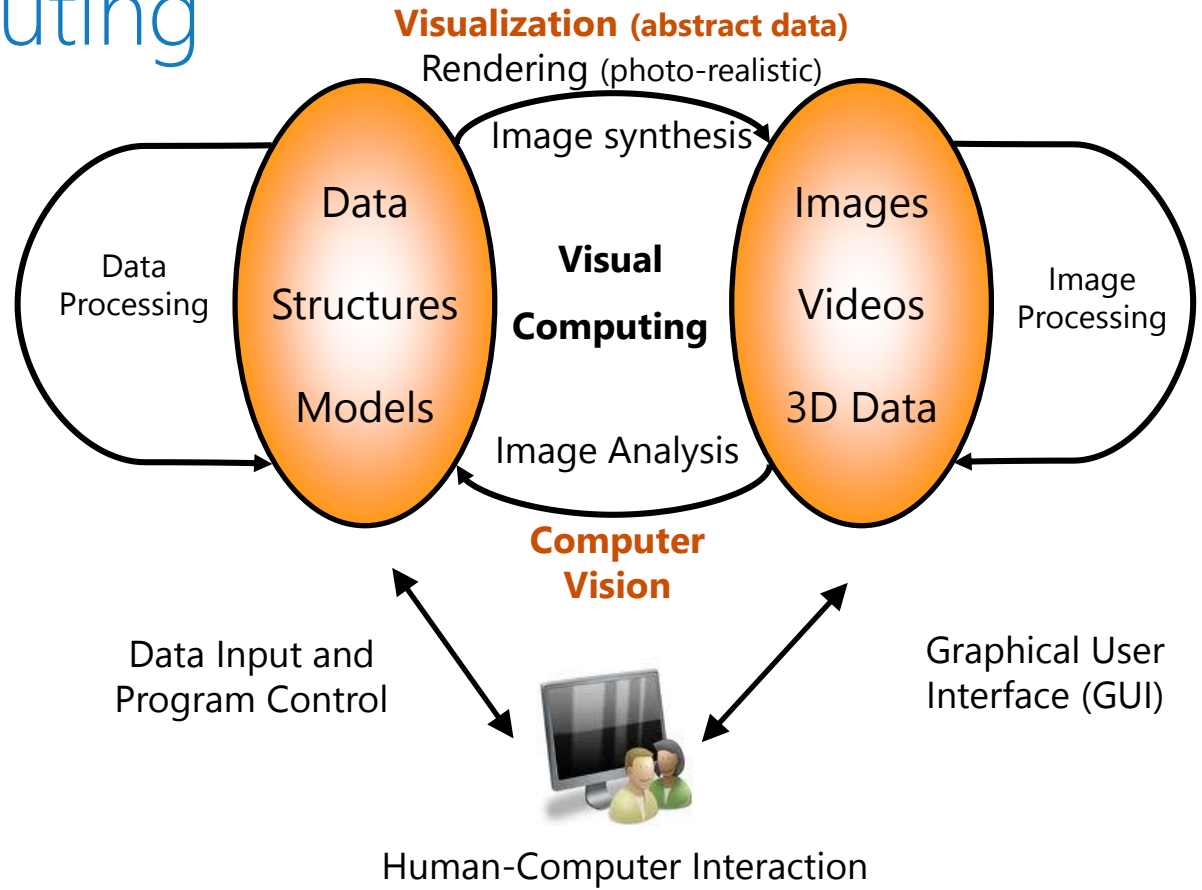
- “The science of analytical reasoning facilitated by interactive visual interfaces”
- Rather new research field
  - Started around 2005
- Targets complex analysis problems
  - Ill-defined search
  - Hypothesis building
  - Dissemination and presentation

Visual Analytics

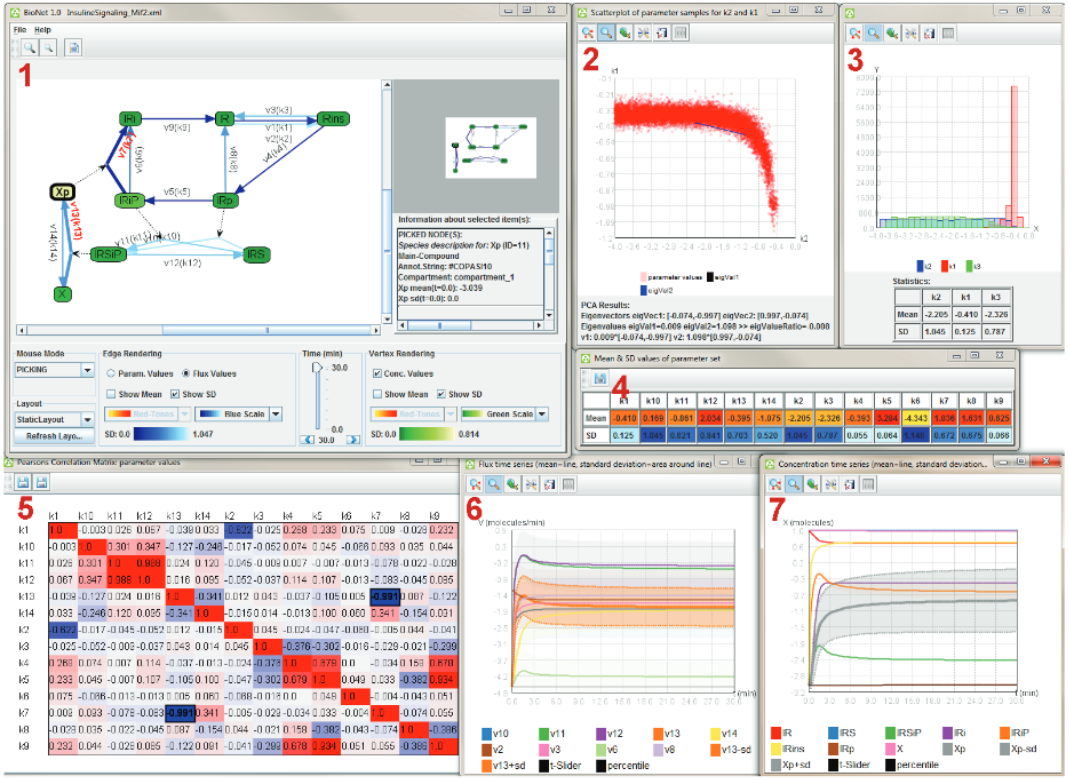


- Combine and balance
  - User-based
  - Automatic (machine-based) analysis

Visual Computing



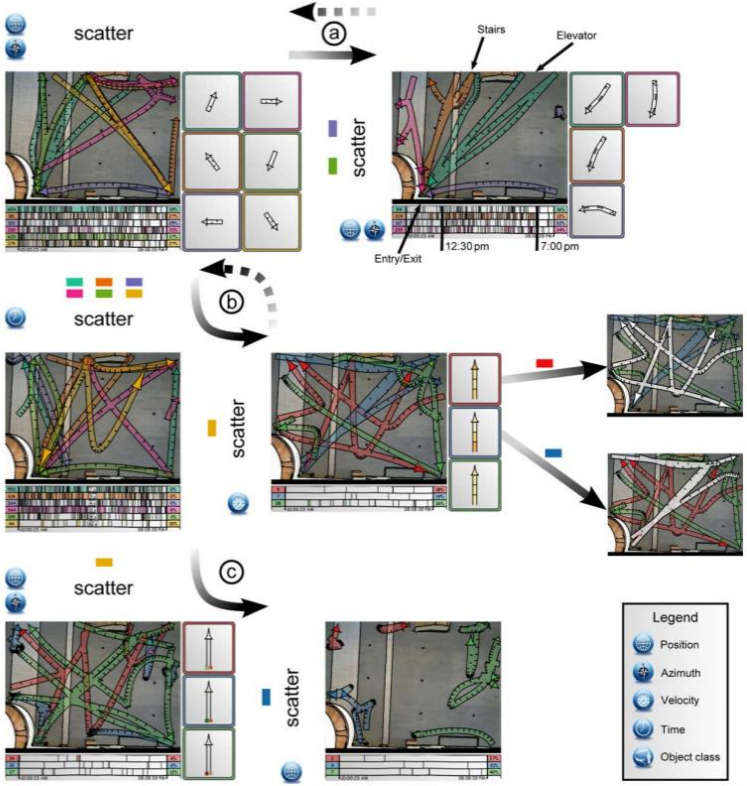
Examples of Visual Analytics



Application in systems biology: biochemical reaction networks

Image: Vehlow, Hasenauer, Kramer, Heinrich, Radde, Allgöwer, D. Weiskopf. BioVis 2012

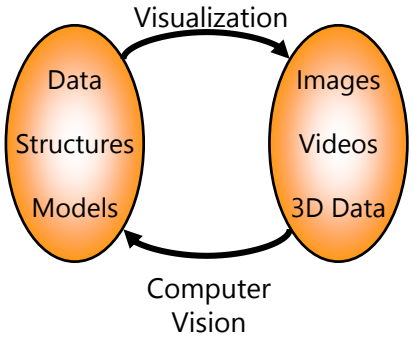
Examples of Visual Analytics



Clustering and data-drill down for trajectories

Image: Höferlin, Höferlin, Heidemann, Weiskopf: IEEE Trans. Multimedia 2013

Examples of Visual Analytics



Inter-active learning of ad-hoc video classifiers **(explainable AI)**

SimTech

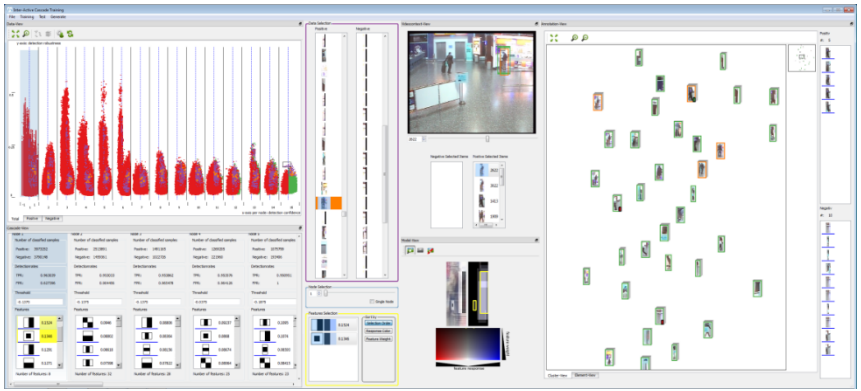


Image: Höferlin, Netzel, Höferlin, Weiskopf, Heidemann.
IEEE VAST 2012

Snooker skill training

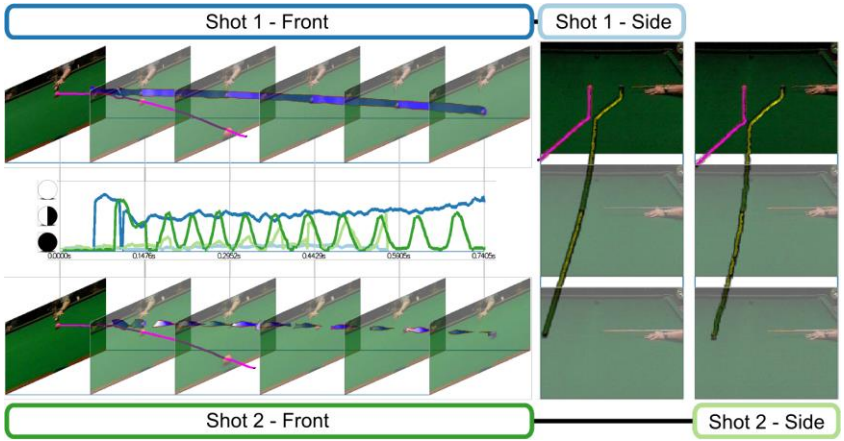
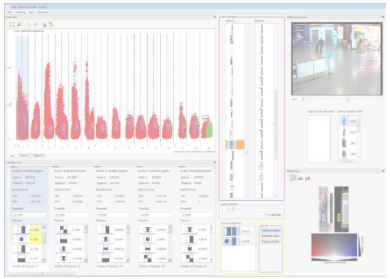


Image: Höferlin, Grundy, Borgo, Weiskopf, Chen, Griffiths, Griffiths. Comput. Graph. Forum 2010

AR and VR



Visual analytics

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Immersion (AR/VR)

= Immersive analytics

Immersion and AR/VR

- Immersed into virtual representation
- Reality–virtuality continuum

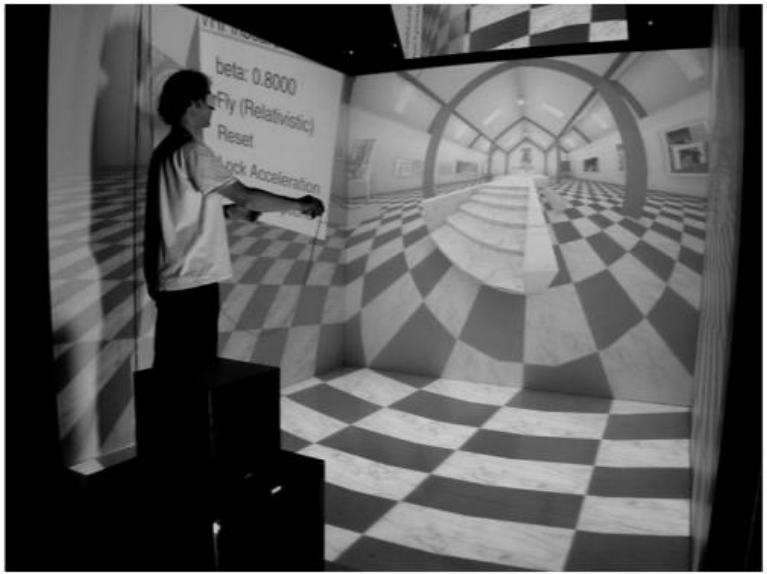
Image: https://en.wikipedia.org/w/index.php?curid=14356884

Technological Advancements

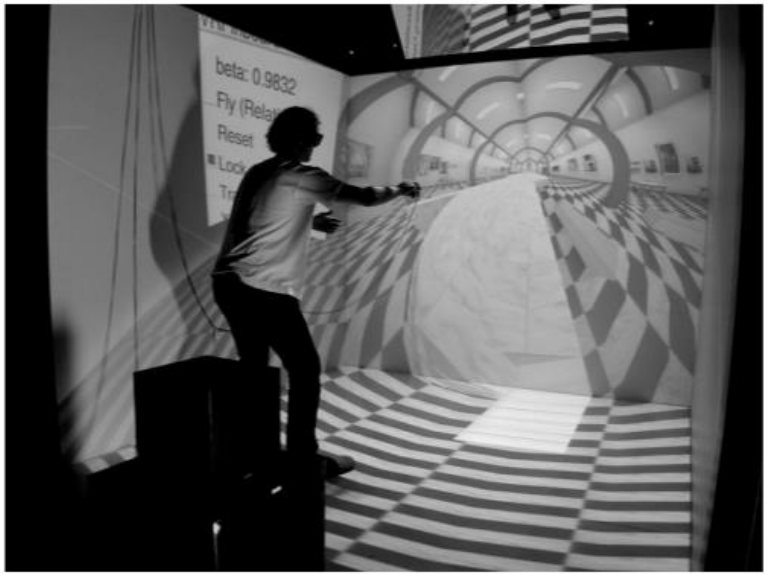
- Much work on VR and AR already in the 1990s
- For example: CAVE system at the University of Chicago in 1992

- New strong boost recently:
  - Display technology
  - Sensors and methods for positioning and image recording
  - Efficient rendering
  - Small scale and wearable devices, head-mounted displays

Example: Virtual Special Relativity



80% speed of light



98.32% speed of light

Images: Weiskopf. WSCG 2000

Virtual relativity in a CAVE

Example: Virtual Special Relativity

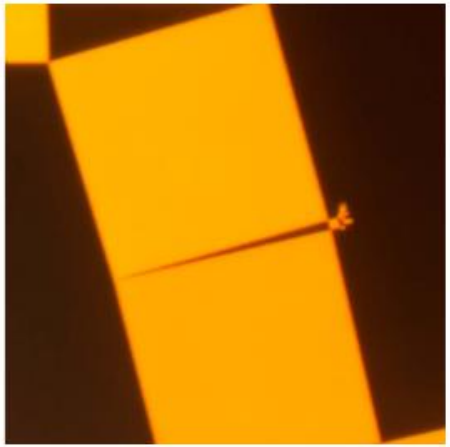
Image: Weiskopf et al. IEEE Trans. Vis. Comput. Graph. 2006

Visualization on Hires Display Walls

Image: Schmauder, Burch, Müller, Weiskopf. BDVA 2015

Visualization on Hires Display Walls

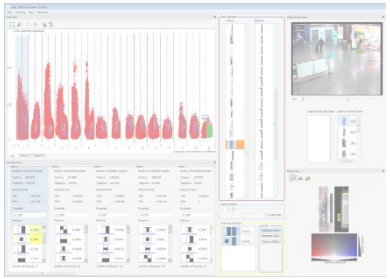




Pictures taken increasingly closer to the Powerwall

Images: Schmauder, Burch, Müller, Weiskopf. BDVA 2015

Immersive Analytics



Visual analytics

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Immersion
(AR/VR)

= **Immersive analytics**

Immersive Analytics

- New trend
- Why useful?
  - Situated analytics
  - Collaborative analytics
- New challenges
  - Interaction
  - 3D vs. 2D
  - Spatialization and context

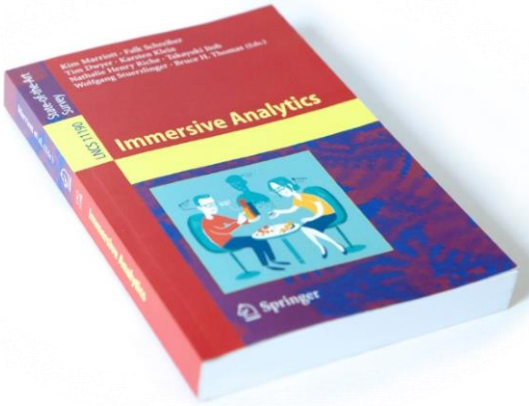
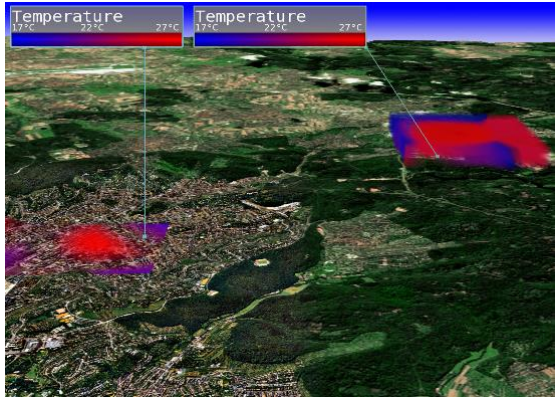
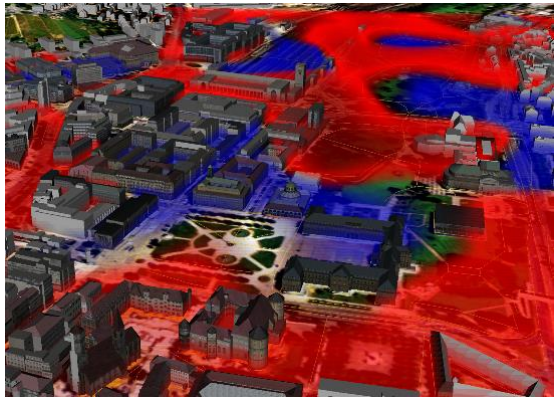


Image © D. Weiskopf

Situated Visualization

- Geo-mashup
- Spatialization given

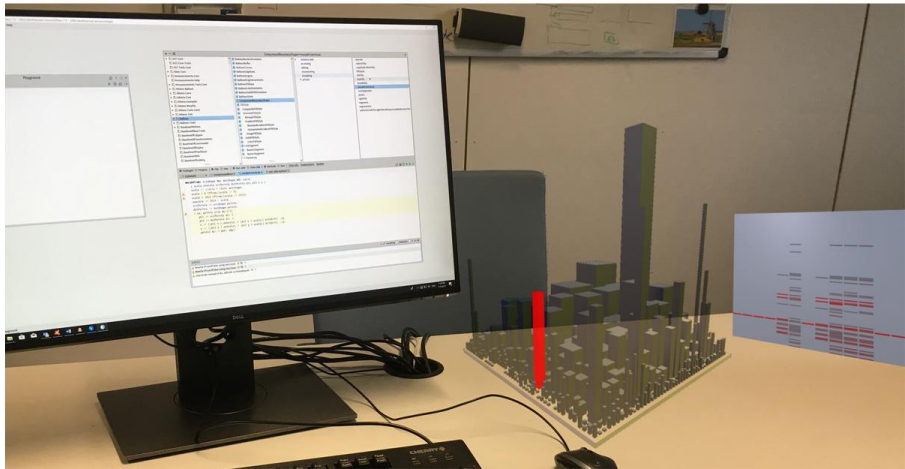




Images: Eissele, Weiskopf, Ertl. Smart Graphics 2009

Spatialization

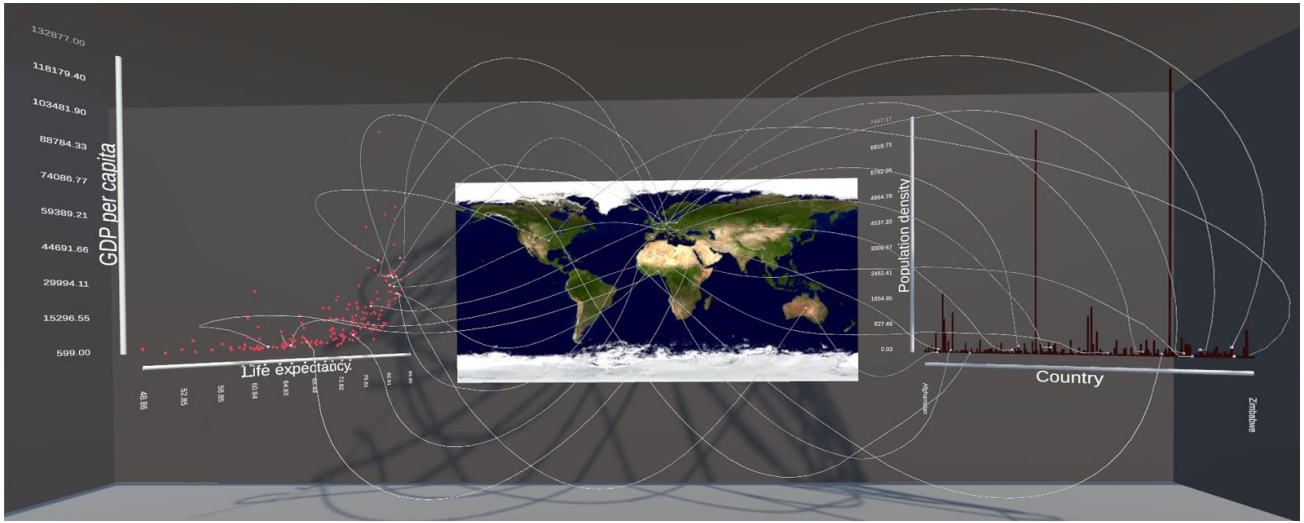
- Example: pervasive software visual analytics for performance analysis
- AR headset + regular desktop environment
- Spatialization of abstract data



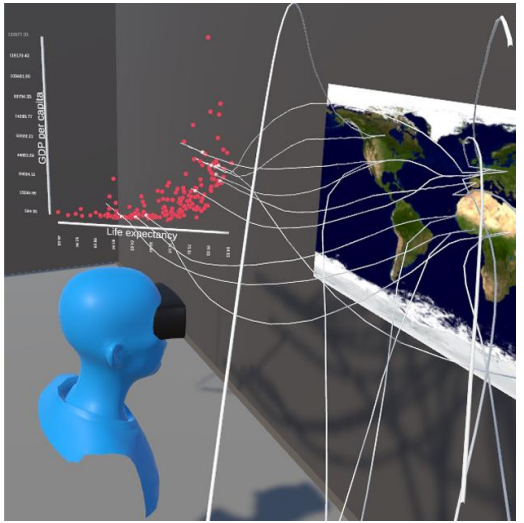
Images: Merino, Hess, Bergel, Nierstrasz, Weiskopf. ICPE ‘19 Companion

Visual Link Routing for HMDs

Linking abstract and spatial data



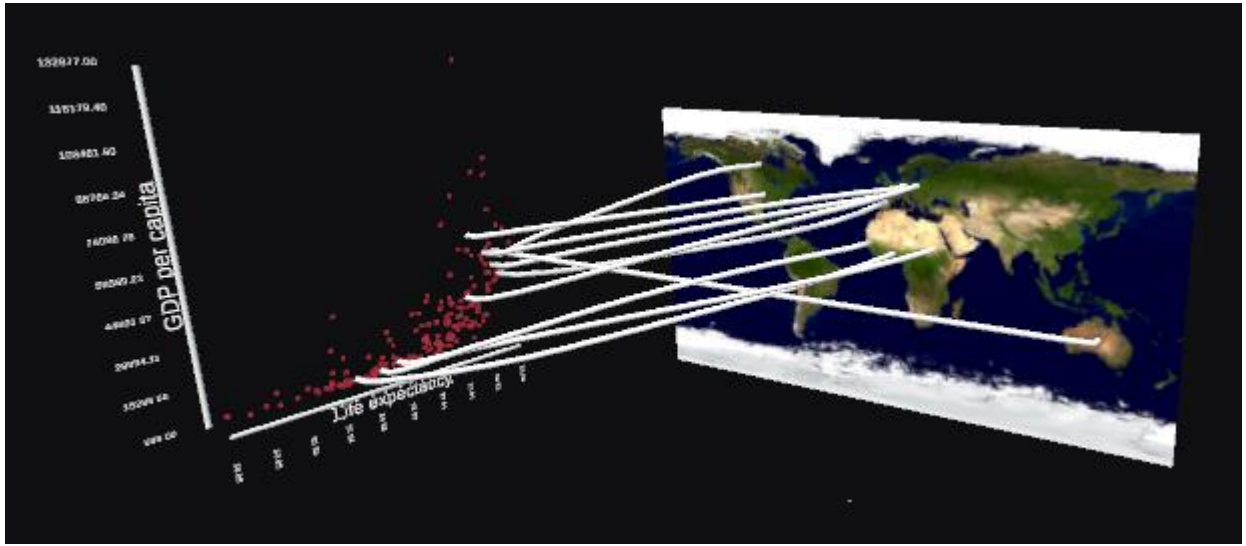
User's view



Outside view

Image: Prouzeau, Lhuillier, Ens, Weiskopf, Dwyer. ISS 2019

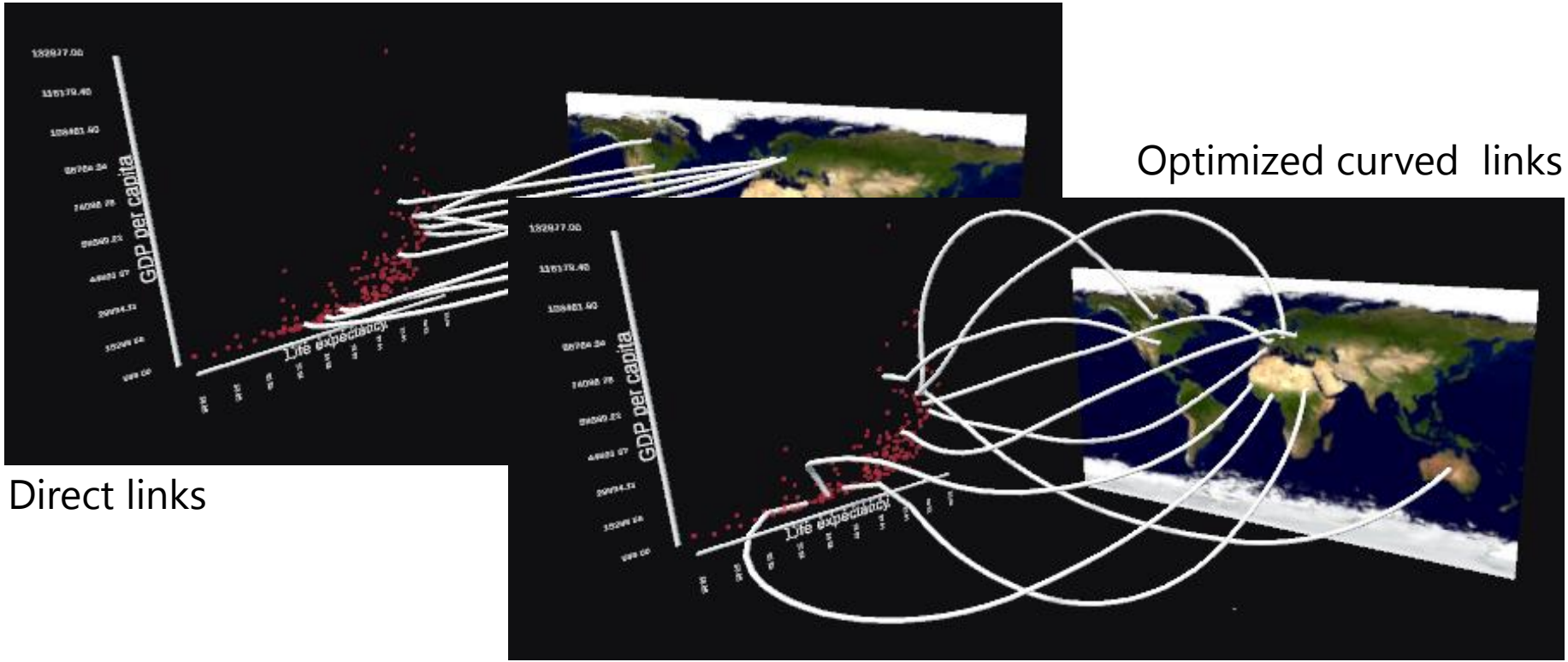
Visual Link Routing



Direct links

Image: Prouzeau, Lhuillier, Ens, Weiskopf, Dwyer. ISS 2019

Visual Link Routing

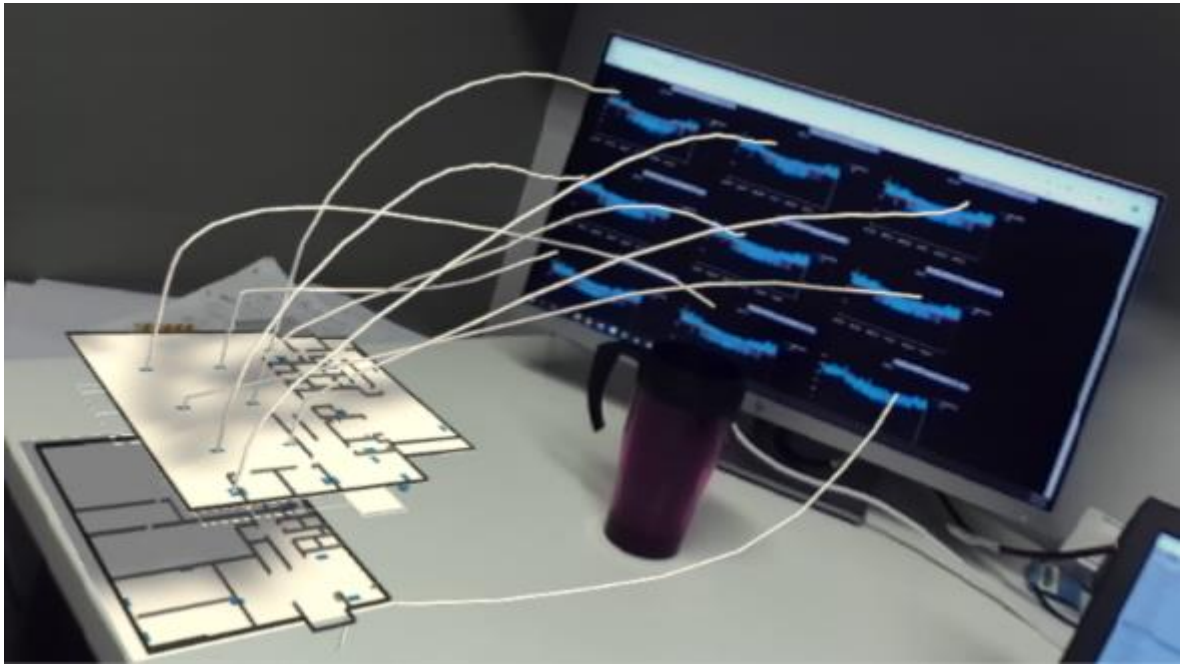


Optimized curved links

Direct links

Image: Prouzeau, Lhuillier, Ens, Weiskopf, Dwyer. ISS 2019

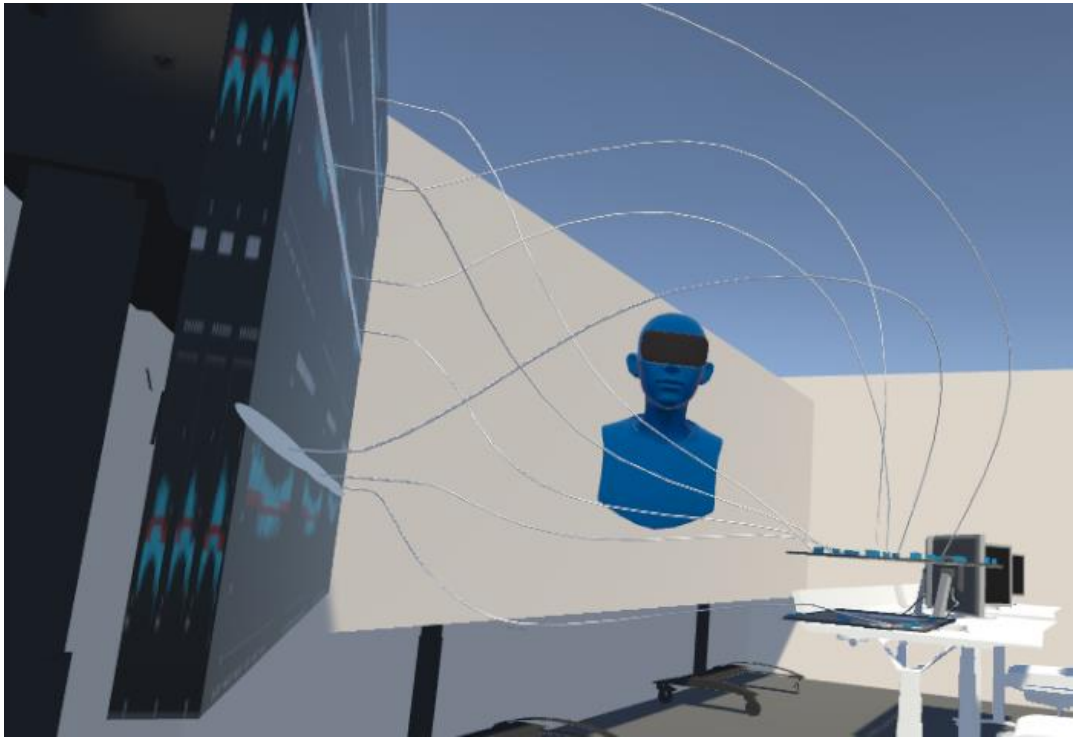
Visual Link Routing



Avoiding obstacle

Image: Prouzeau, Lhuillier, Ens, Weiskopf, Dwyer. ISS 2019

Visual Link Routing



Use in collaborative immersive analytics

Image: Prouzeau, Lhuillier, Ens, Weiskopf, Dwyer. ISS 2019

Applications

- Industrie 4.0
- Integrative computational design and construction for architecture

Perspectives

- Improved user modeling
- Implicit interaction
- Pervasive gaze sensing

- Higher level of automatization than in desktop visual analytics
- Larger range of target audiences

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SimTech

IntCDC

SFB-TRR 161
Transregional Collaborative Research Center
Quantitative Methods for Visual Computing

www.sfbtrr161.de
www.visual-computing.org

Thank You!

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Gefördert durch
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