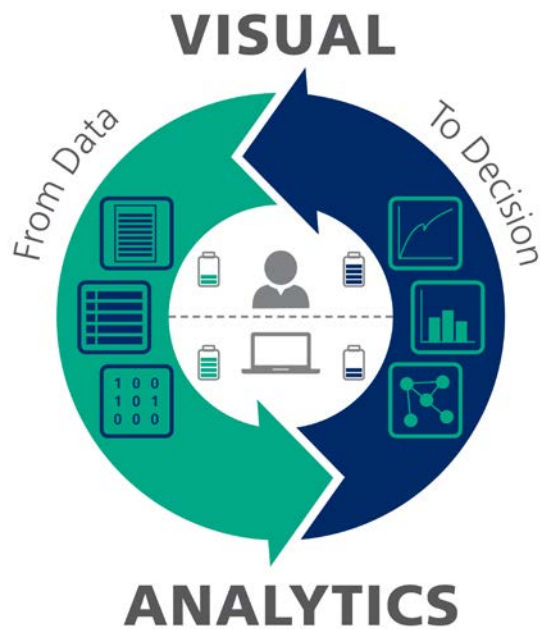


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# VISUAL ANALYSIS OF LONGITUDINAL CLINICAL DATA

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[www.igd.fraunhofer.de/IVA](http://www.igd.fraunhofer.de/IVA)

# Fraunhofer IGD

Stand 2016

## Die international führende Einrichtung für angewandtes Visual Computing

233 Beschäftigte (FTE)

20,7 Mio € Budget

4 Standorte  
Darmstadt  
Rostock  
Graz  
Singapur

13 F&E-Abteilungen



Rostock



Darmstadt



Graz

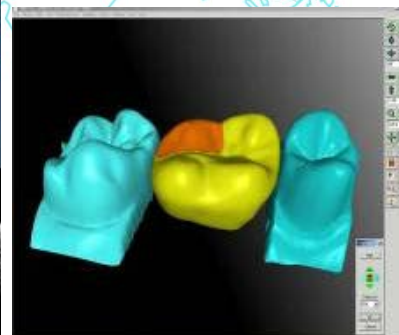
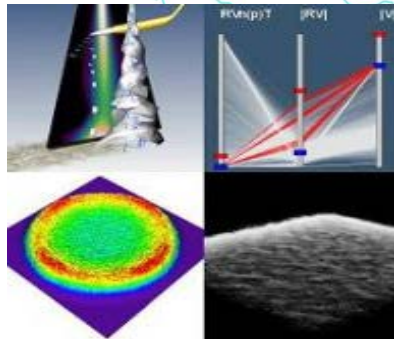


Singapur

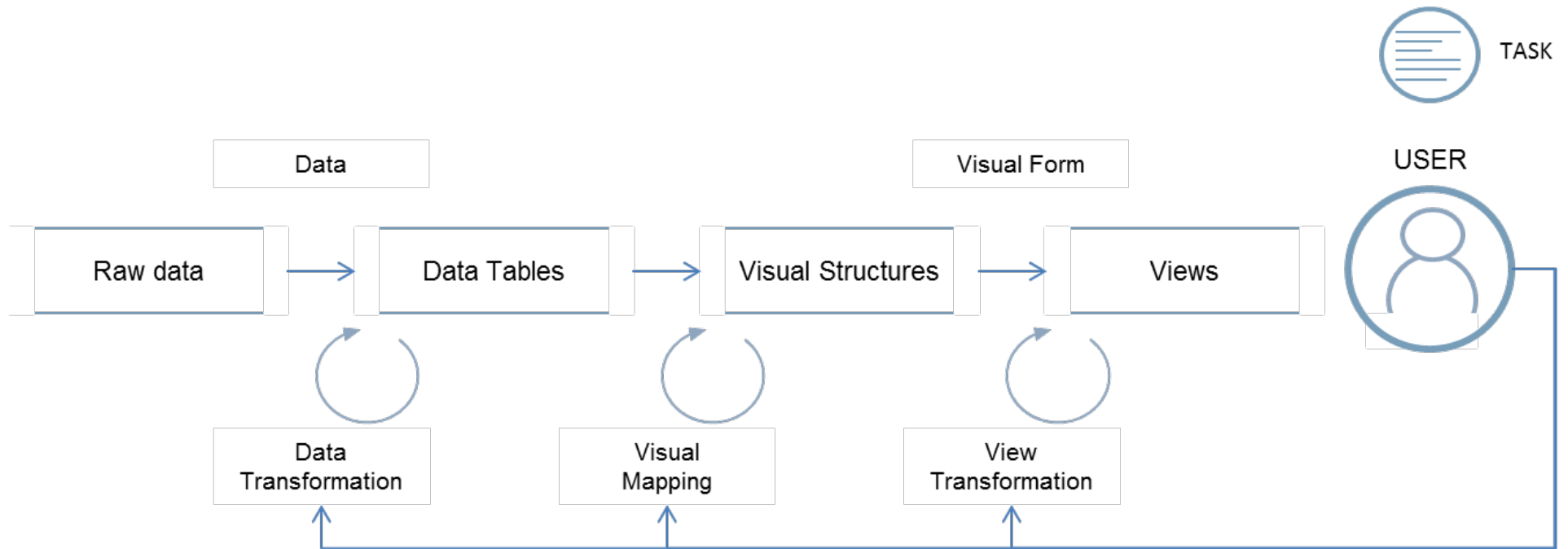
# Fraunhofer IGD Darmstadt

## ■ Competence Centers

- Interactive Multimedia Appliances
- Interactive Engineering Technologies
- Information Visualization and Visual Analytics
- Virtual and Augmented Reality
- Spatial Information Management
- Medical Imaging and Cognitive Computing
- Identification and Biometrics
- Visual Computing System Technologies
- Cultural Heritage Digitization



# Information Visualization

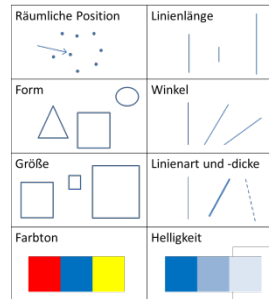


Adapted from Card et al. 1999

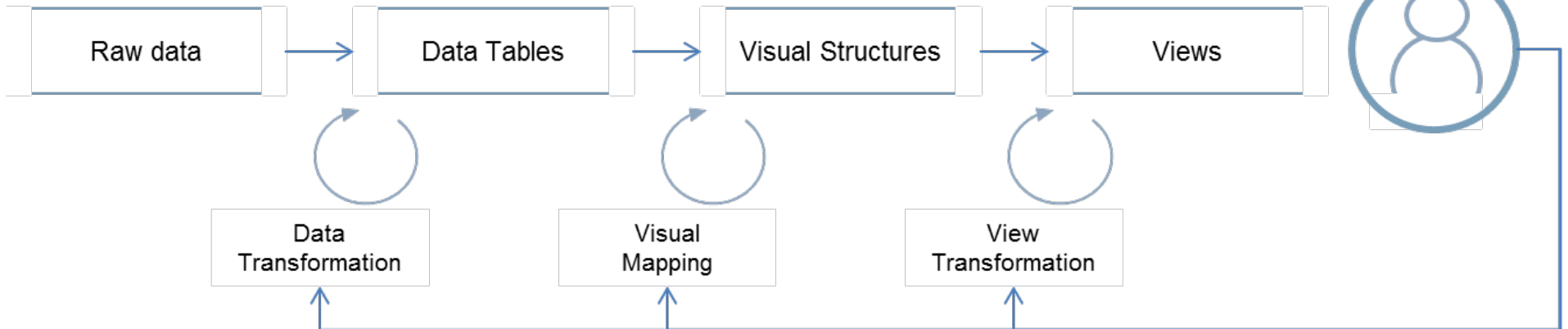
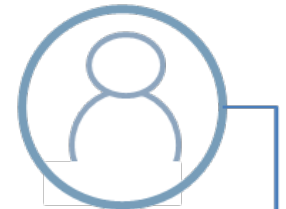
# Information Visualization



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Feder-Winterzeit	7,22	8,28	9,27	9,78	11,23	12,04	12,13	13,43	14,61	14,29	14,53	14,13	14,87	
Feder	6,93	7,74	8,24	8,84	10,28	11,09	11,29	12,59	13,77	13,45	13,69	13,29	14,03	
Feder	11,28	12,28	12,94	13,61	14,41	15,24	15,91	16,61	17,28	17,95	18,61	19,27	19,94	
Hochsommer	11,28	11,88	12,49	13,10	13,71	14,32	14,93	15,54	16,15	16,76	17,37	17,98	18,59	
Hochsommer	6,87	6,23	5,24	4,84	3,89	3,24	2,59	1,94	1,29	0,64	0,00	0,00	0,00	
Hochsommer	12,41	13,44	14,36	15,09	16,17	17,21	18,25	19,29	20,33	20,27	20,21	20,20	20,20	
Herbst	11,82	11,71	11,93	12,24	12,65	13,06	13,47	13,88	14,29	14,70	15,11	15,52	15,93	
Herbst	13,10	13,51	13,92	14,33	14,74	15,15	15,56	15,97	16,38	16,79	17,20	17,61	18,02	
Herbst	22,30	22,31	22,32	22,33	22,34	22,35	22,36	22,37	22,38	22,39	22,40	22,41	22,42	
Herbst	12,70	12,80	12,90	13,00	13,10	13,20	13,30	13,40	13,50	13,60	13,70	13,80	13,90	
Herbst	12,70	12,80	12,90	13,00	13,10	13,20	13,30	13,40	13,50	13,60	13,70	13,80	13,90	
Herbst	23,51	23,52	23,53	23,54	23,55	23,56	23,57	23,58	23,59	23,60	23,61	23,62	23,63	
Herbst	16,77	16,78	16,79	16,80	16,81	16,82	16,83	16,84	16,85	16,86	16,87	16,88	16,89	
Herbst	16,77	16,78	16,79	16,80	16,81	16,82	16,83	16,84	16,85	16,86	16,87	16,88	16,89	
Herbst	14,23	14,24	14,25	14,26	14,27	14,28	14,29	14,30	14,31	14,32	14,33	14,34	14,35	
Herbst	5,6	5,62	5,64	5,66	5,68	5,70	5,72	5,74	5,76	5,78	5,80	5,82	5,84	
Herbst	13,04	13,06	13,08	13,10	13,12	13,14	13,16	13,18	13,20	13,22	13,24	13,26	13,28	



USER



# Big Data



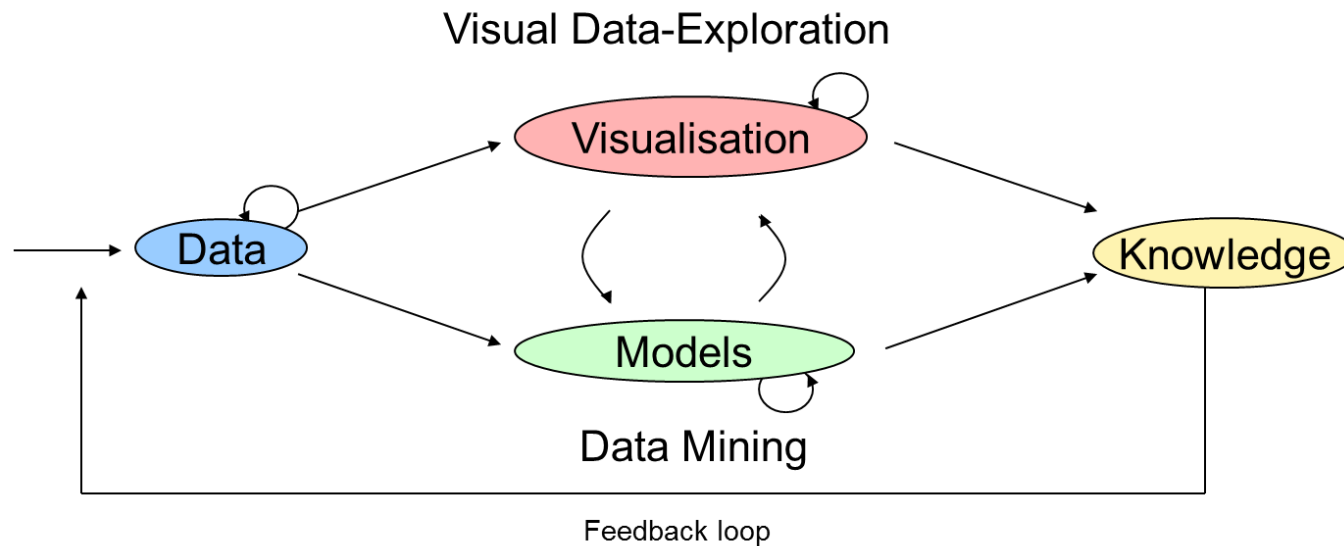
# Visual Analytics

What do we have?

- **Automatic Knowledge Discovery & Data Mining**
- **Interactive Visual Data-Exploration**

What do we need?

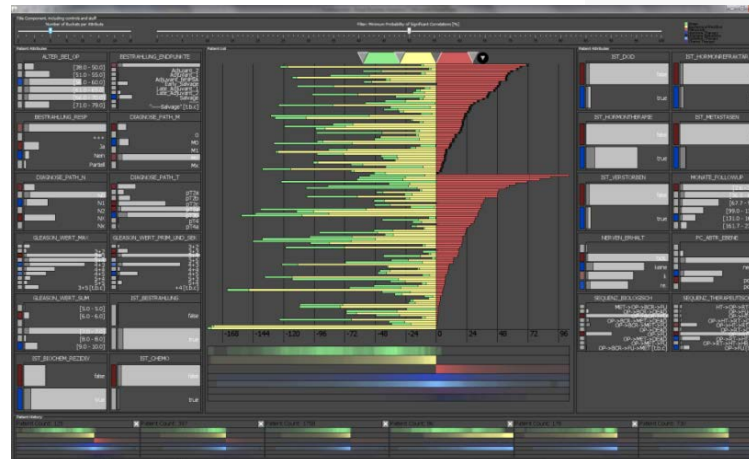
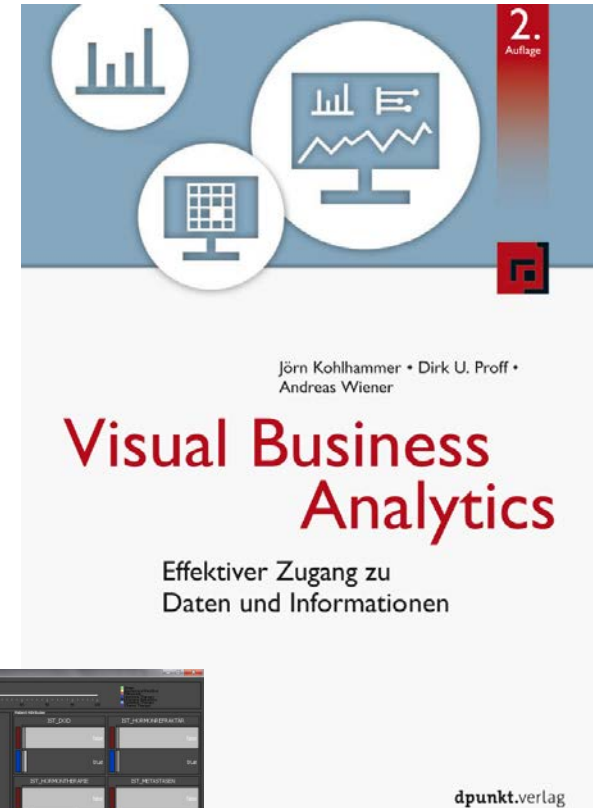
- **Tight Integration of Visual and Automatic Data Analysis Methods with Database Technology for a Scalable Interactive Decision Support**



(Keim, 2008)

# Visual Analytics at Fraunhofer IGD

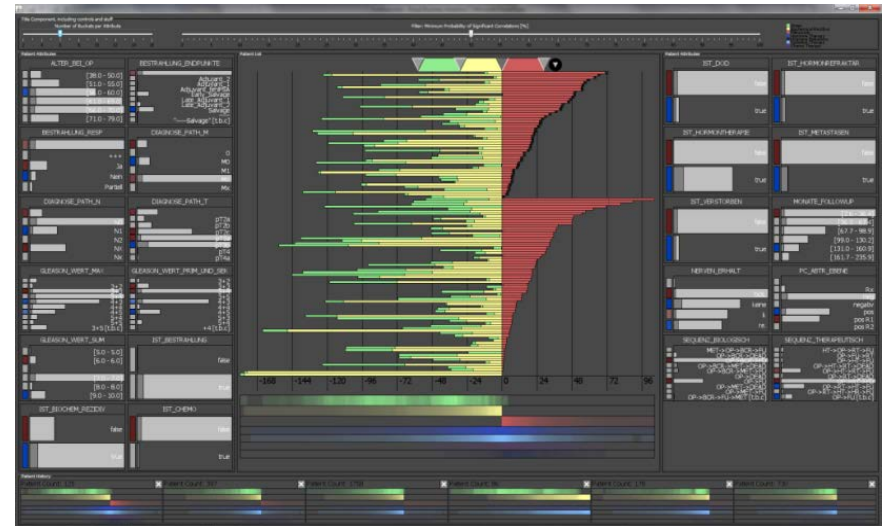
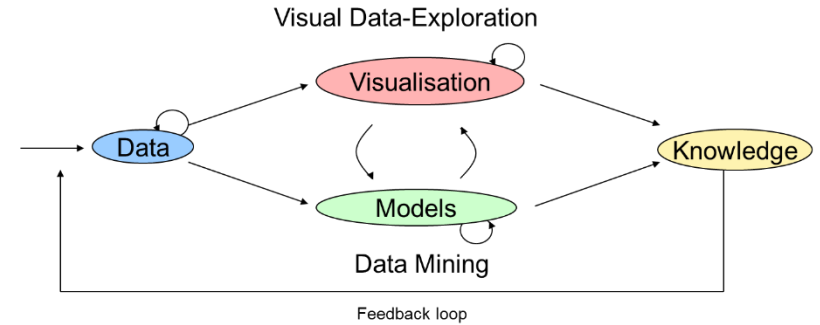
- Visual Business Analytics
- Cyber Security
- Medical Data Analytics
- Sensor Analytics
- Other application where humans have to interact with massive amounts of data
  - Energy networks
  - IT networks





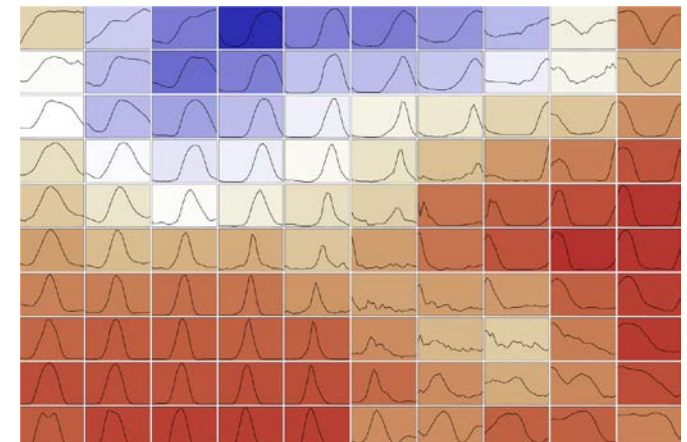
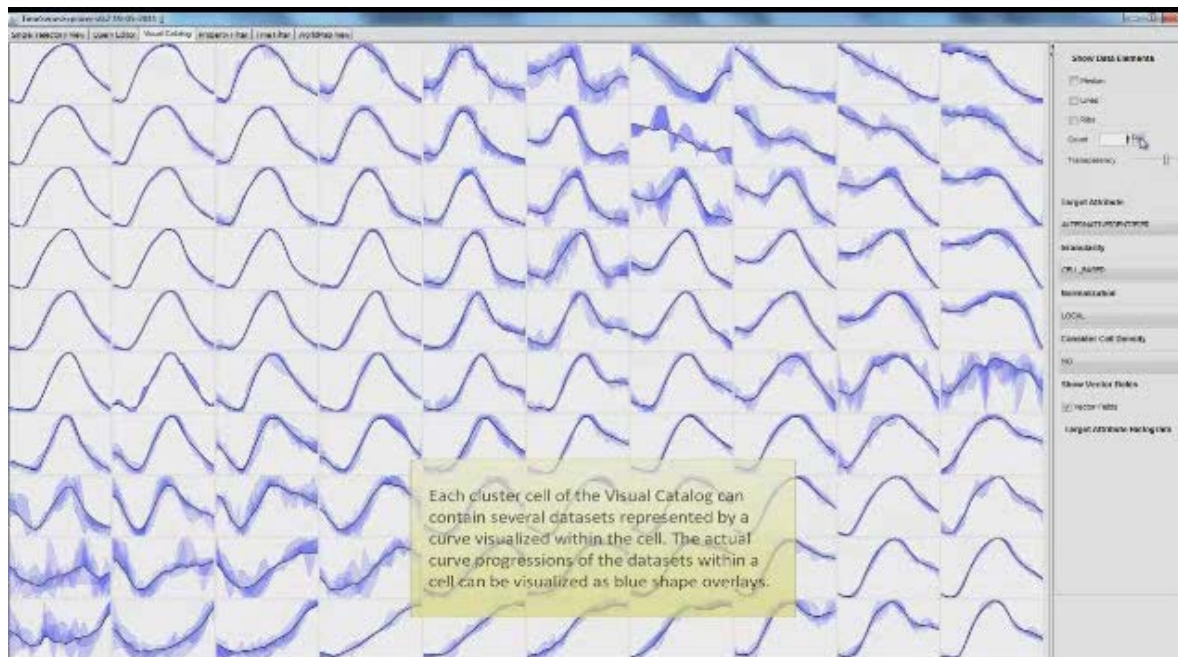
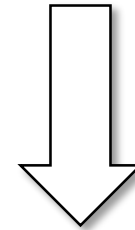
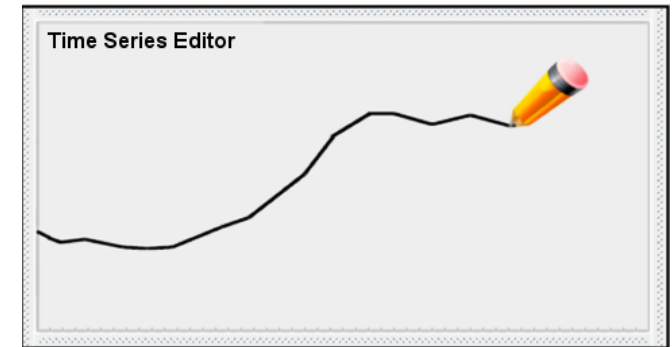
# Combining Visualization and AI to Analyze Health Data

- Interactive definition of cohorts for medical research
- Exploration of patient data with many attributes across long time periods
- Correlation analysis to identify similar patients using health-care records and treatments
- Combination with image-based approaches
- Long-standing collaboration with cancer research in Germany and Europe



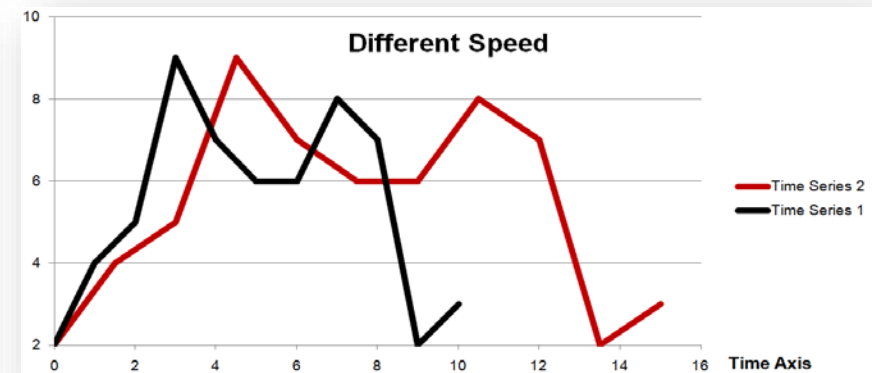
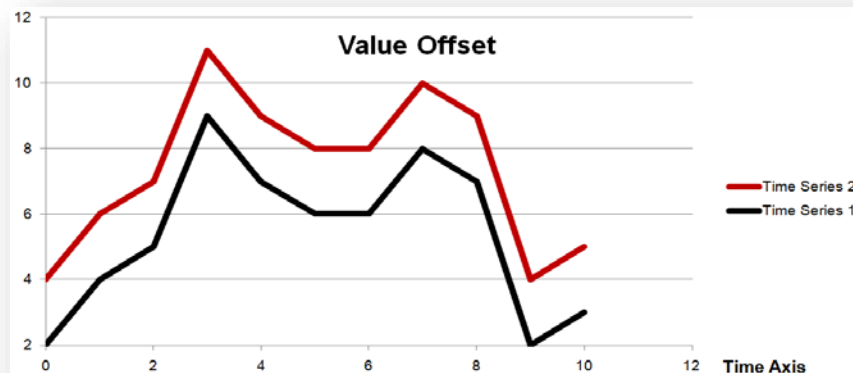
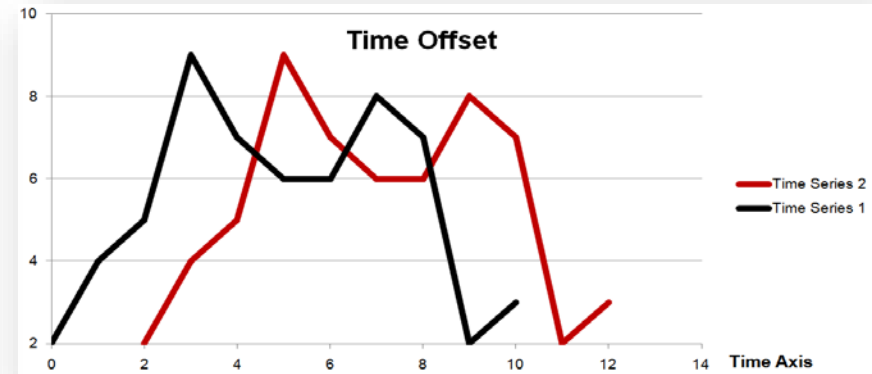
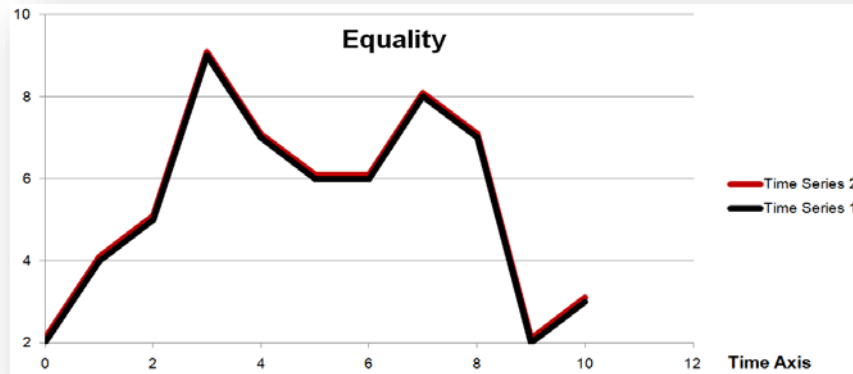
# Visual Analysis of Time-dependent Data

- Interactive manipulation of time series
- Search for similar patterns
- Identification of correlations
- Creation of prediction models



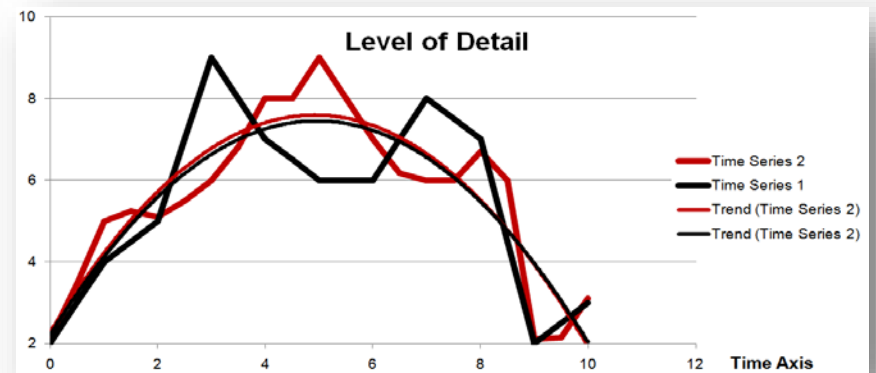
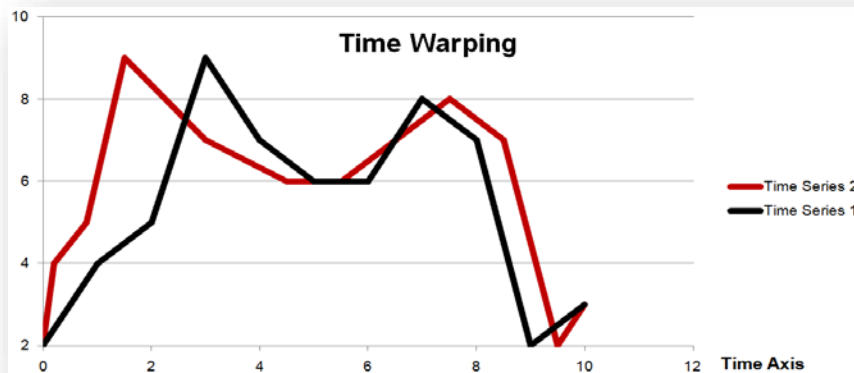
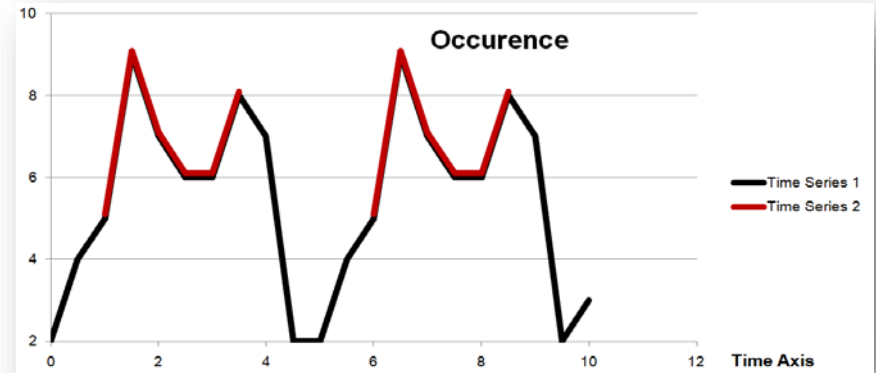
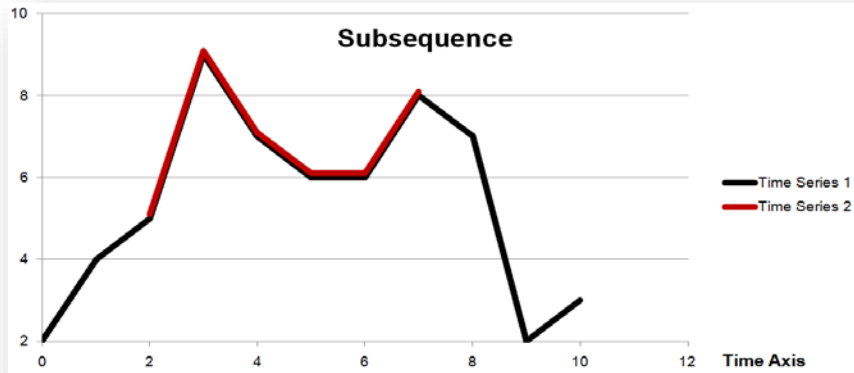
# Similarity

What is the relevant similarity measure?



# Similarity

What is the relevant similarity measure?

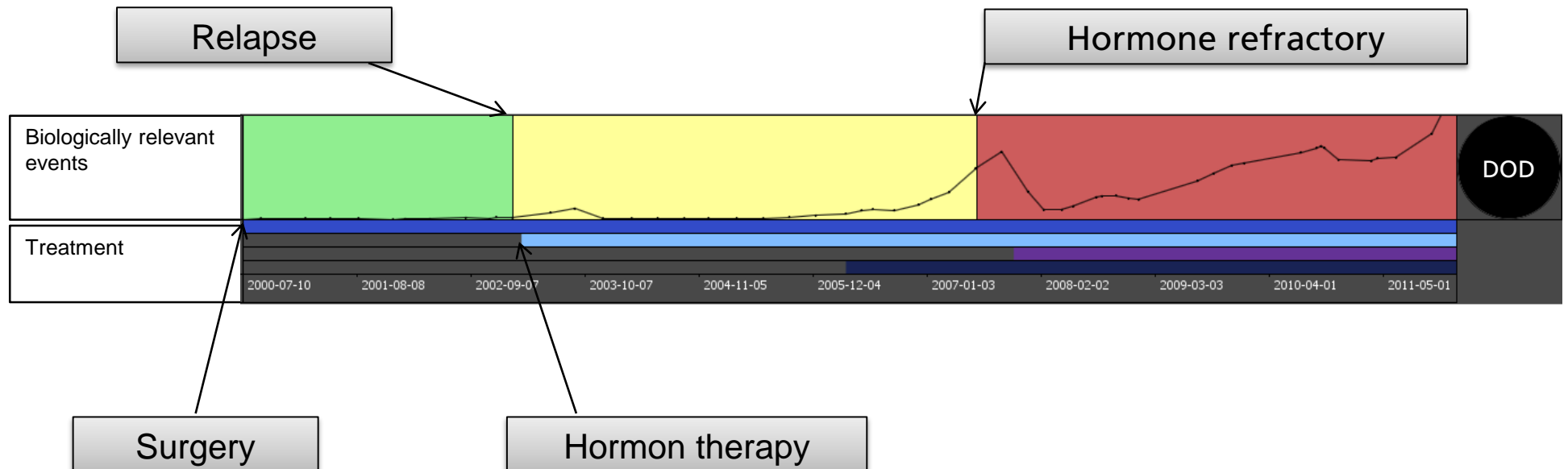


# Interactive Cohort Building

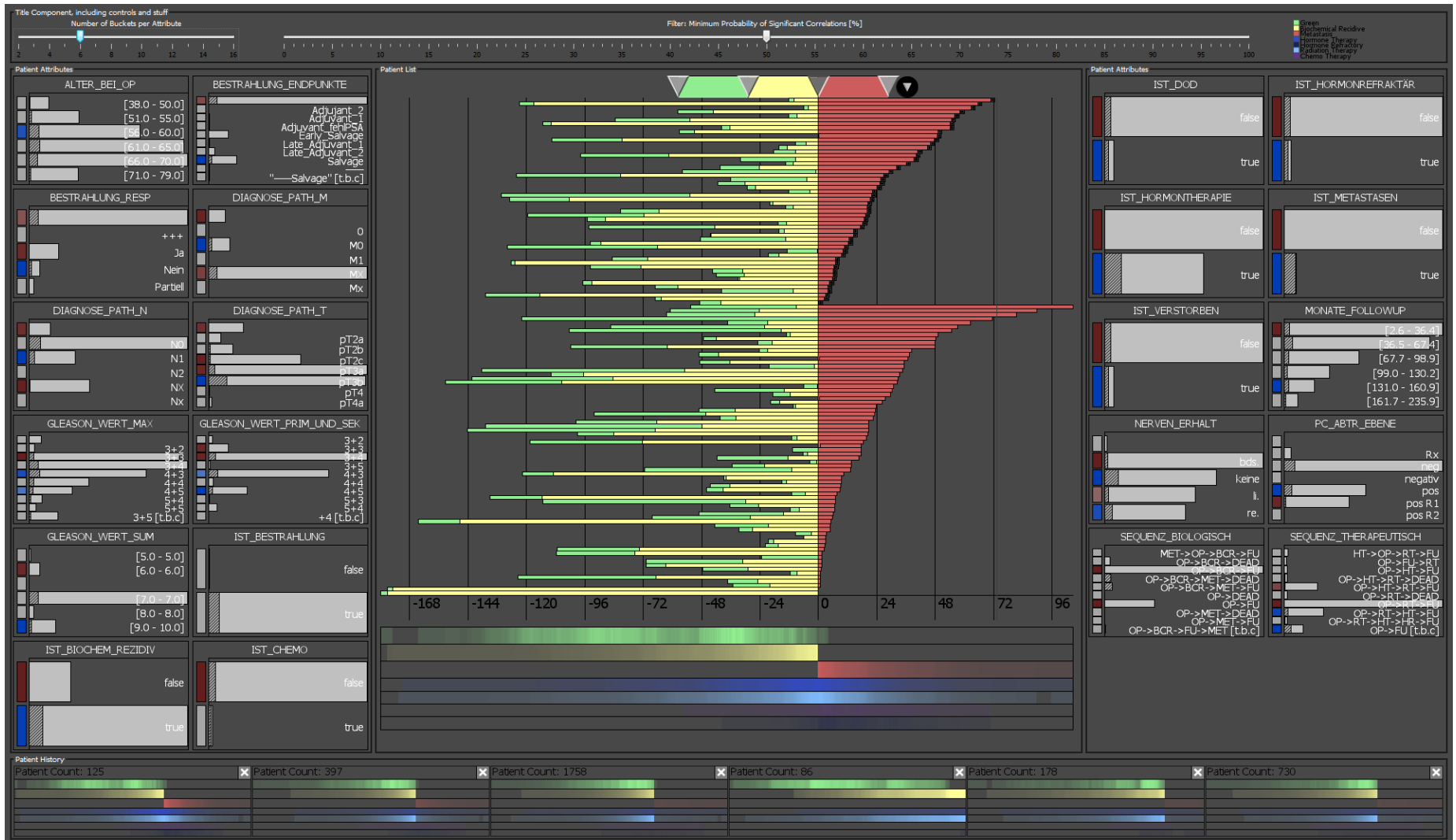
- Database of 20.000 patients with prostate cancer (100 – 200 data values per patient)
  - Disease progression
  - Therapy
  - Follow-up
  
- Statistical analysis: Optimize stratification to enable relevant and strong statistical assertions
  
- Main requirements
  - Visualize as many patients as possible in one view
  - Interactively model cohorts

# Visualization of Patient Histories

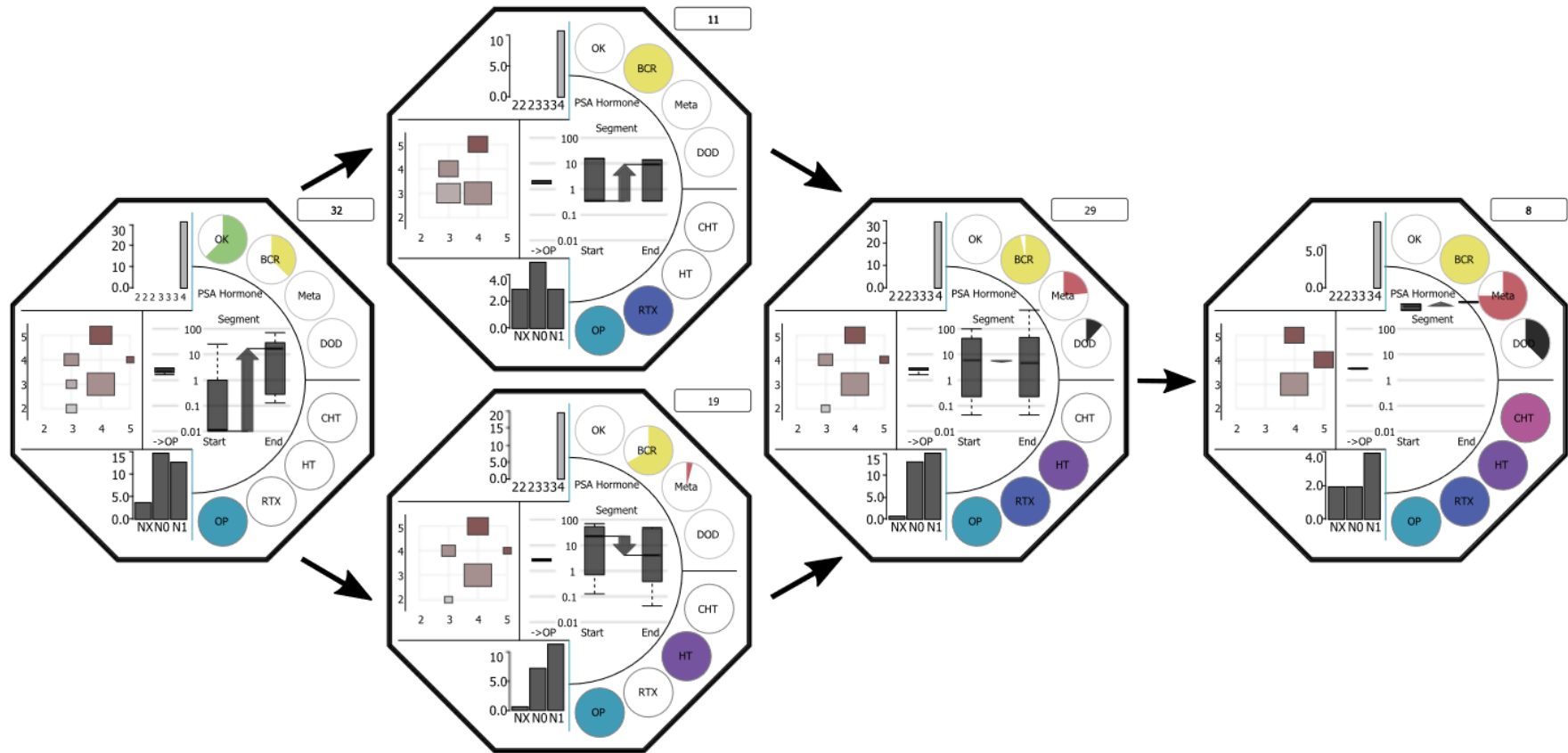
- Comparison of over 20,000 patients and their histories to better predict future events and understand progression of prostate cancer



# Visualization of Patient Histories (Demo)



# Visualization of Multiple Patient Histories

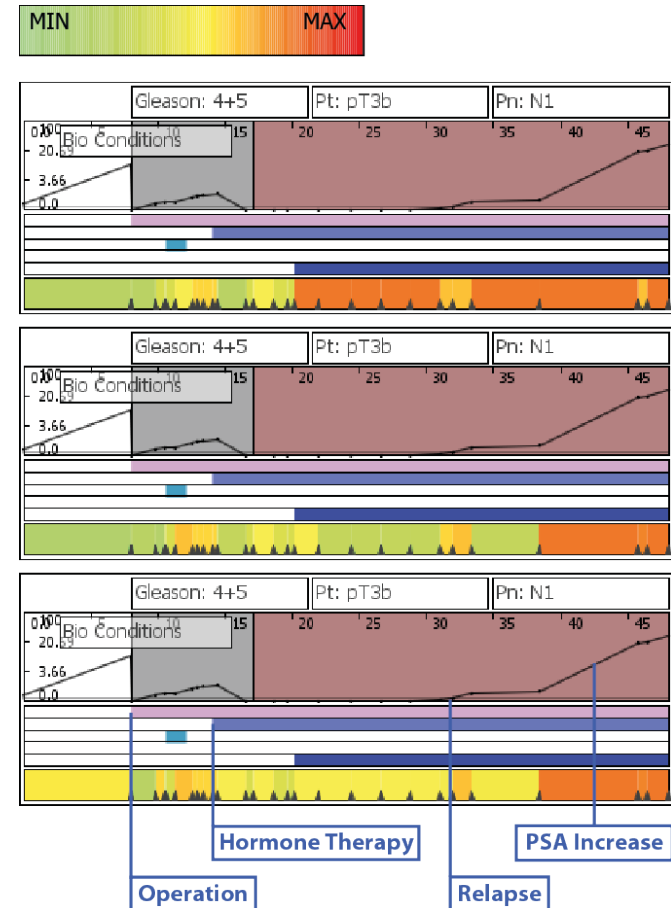


Bernard, Sessler, Kohlhammer, Ruddle, Using Dashboard Networks to Visualize Multiple Patient Histories, IEEE TVCG, 2018

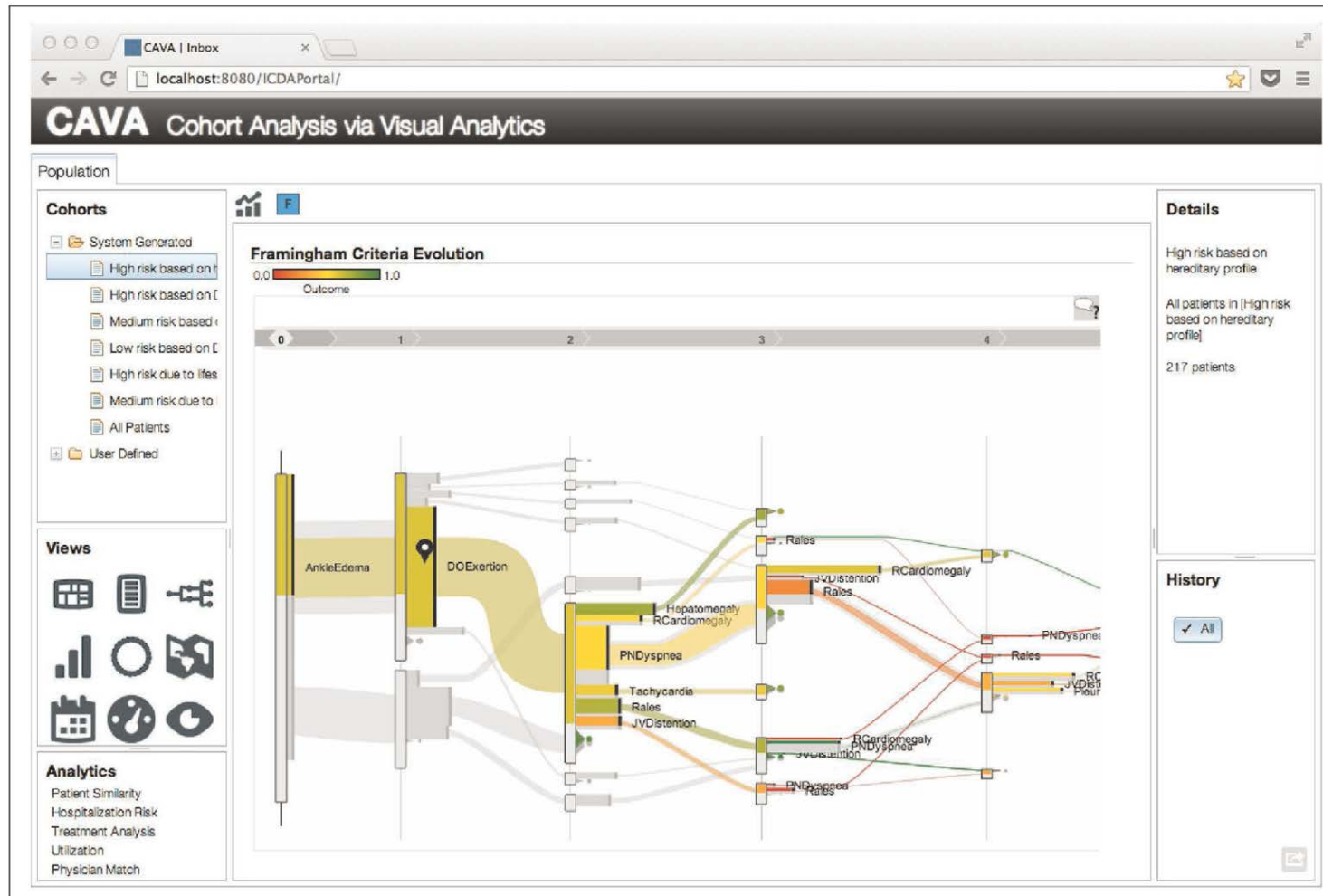


# Combination with ML: Active Learning

- Use of similarity models
- Enhancing the model through feedback of medical experts (well-being of patients depending on disease phase and certain blood values)
- Better understanding of mental models of doctors
- Better understanding of similar patients and cohorts



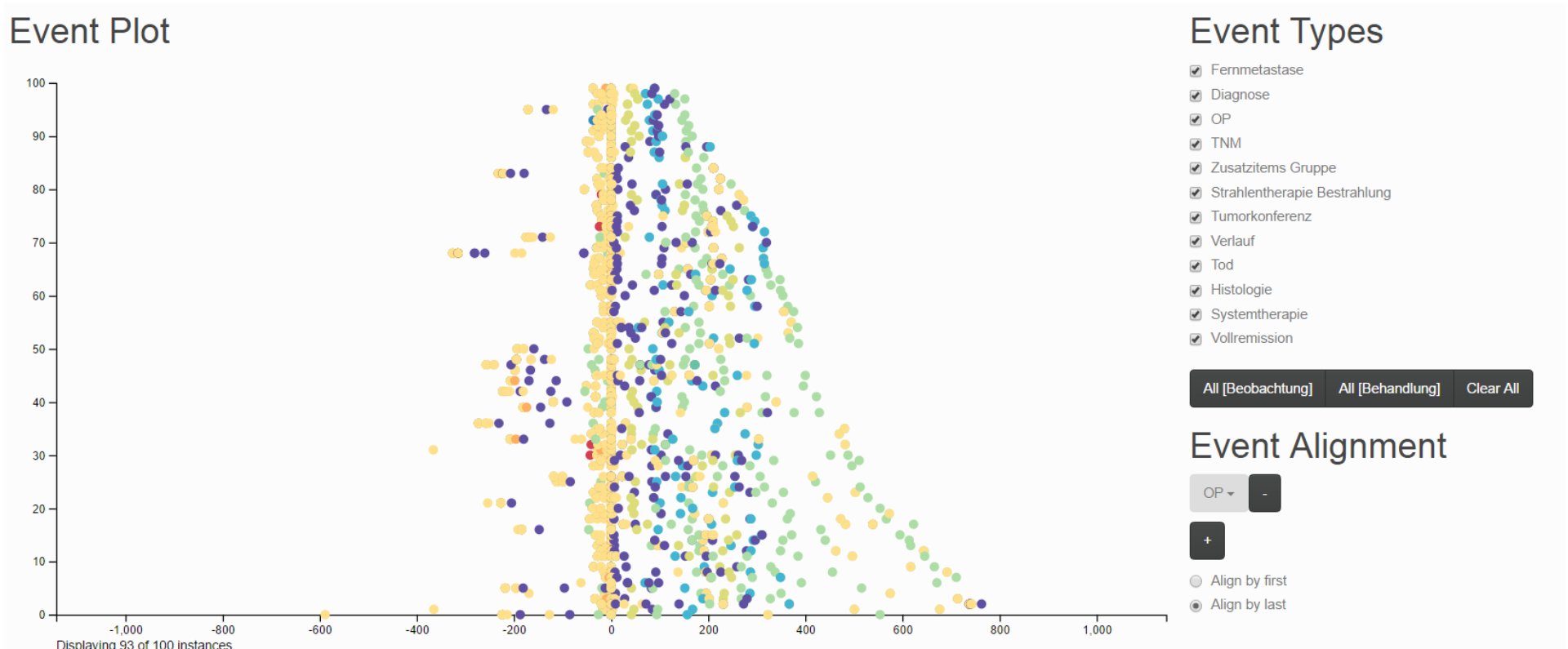
# CAVA



Zhang, Gotz, Perer, Iterative cohort analysis and exploration, Information Visualization Journal, 2014

# Event-based Data

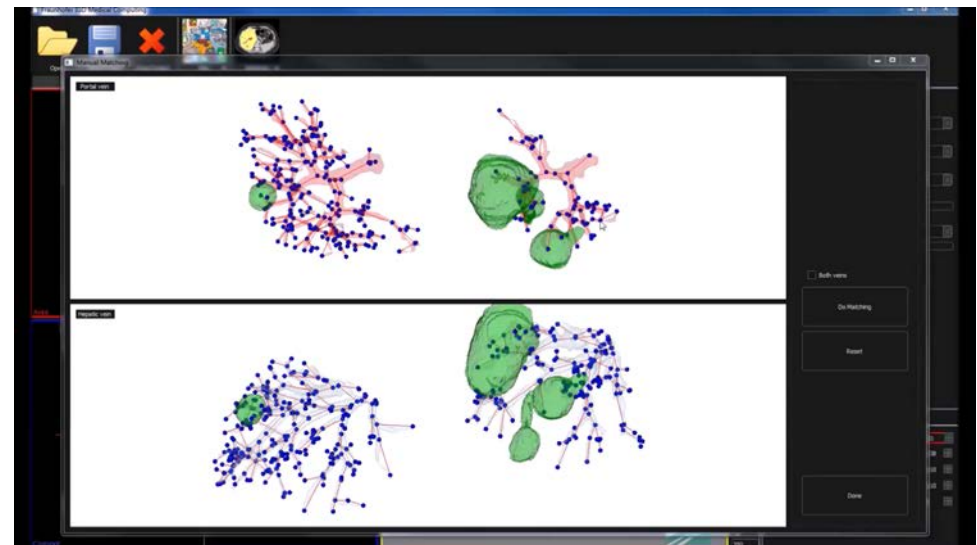
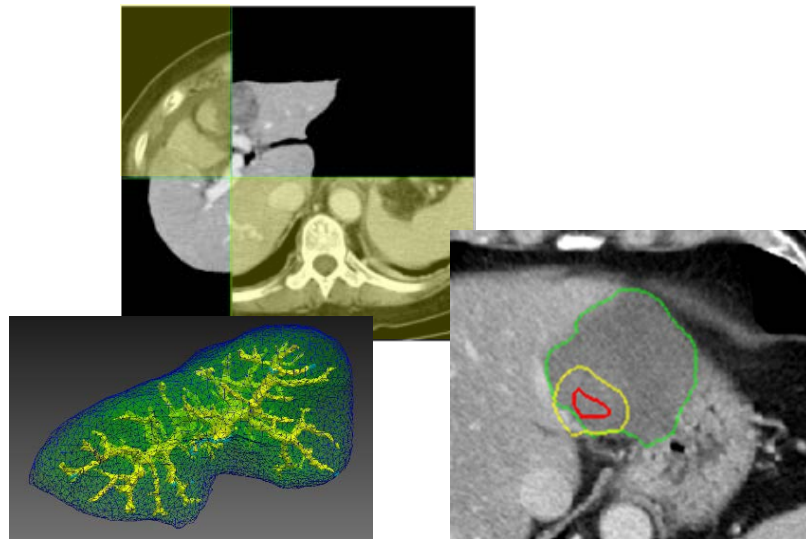
- 100 breast cancer patients with various events over time



# Image-based monitoring of liver interventions

## Graph-based registration of liver CT data

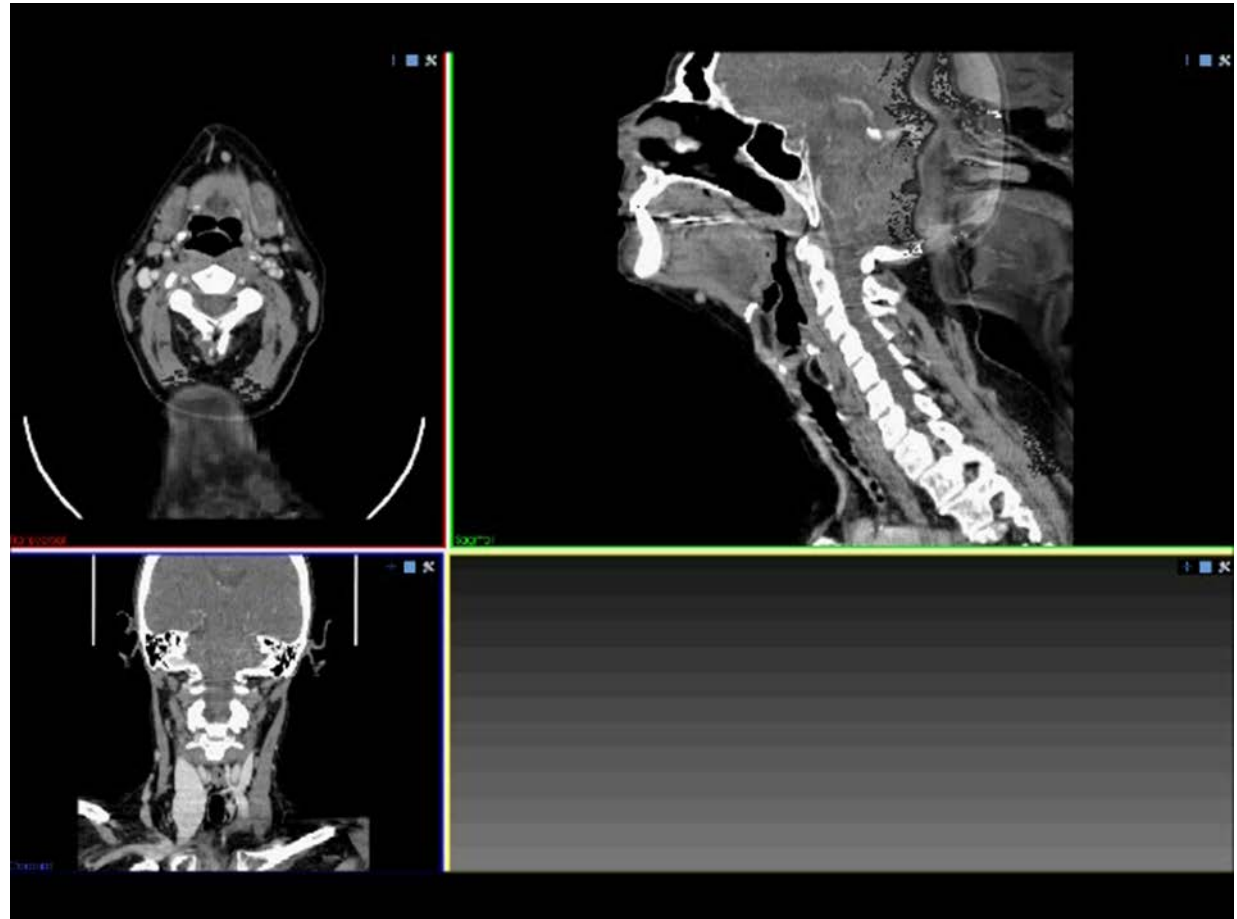
- Control of success of liver tumor ablations
  - ➔ Verification whether **tumor tissue** has been **completely** covered
- Compensation for **tissue deformations** between planning and control scan
- Automatic **pre-/post graph matching** of **liver vessels**



# Longitudinal lymph node monitoring

## Model-based registration of multi-modal head & neck image data

- Lymph node size as an indicator for a relapse  
→ automatically establishing correspondences over time
- Elastic, automatic matching of longitudinal image data



# Conclusion

- Combination of image-based data and patient data over time
- Collaboration on data-driven medicine with clinics
  - Prostate cancer in Berlin (Charité) and Hamburg (UKE)
  - Head and neck cancer in Düsseldorf
  - Breast cancer in Frankfurt (Agaplesion Markus)
- DFG project on segmentation and labeling of multivariate time series
- Large new Fraunhofer initiative on cost-effective medicine
- Visit us at DMEA 2019, Hall 2.2, E109



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# THANK YOU!

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