User-Centered Design of Visual Analytics and AI Solutions

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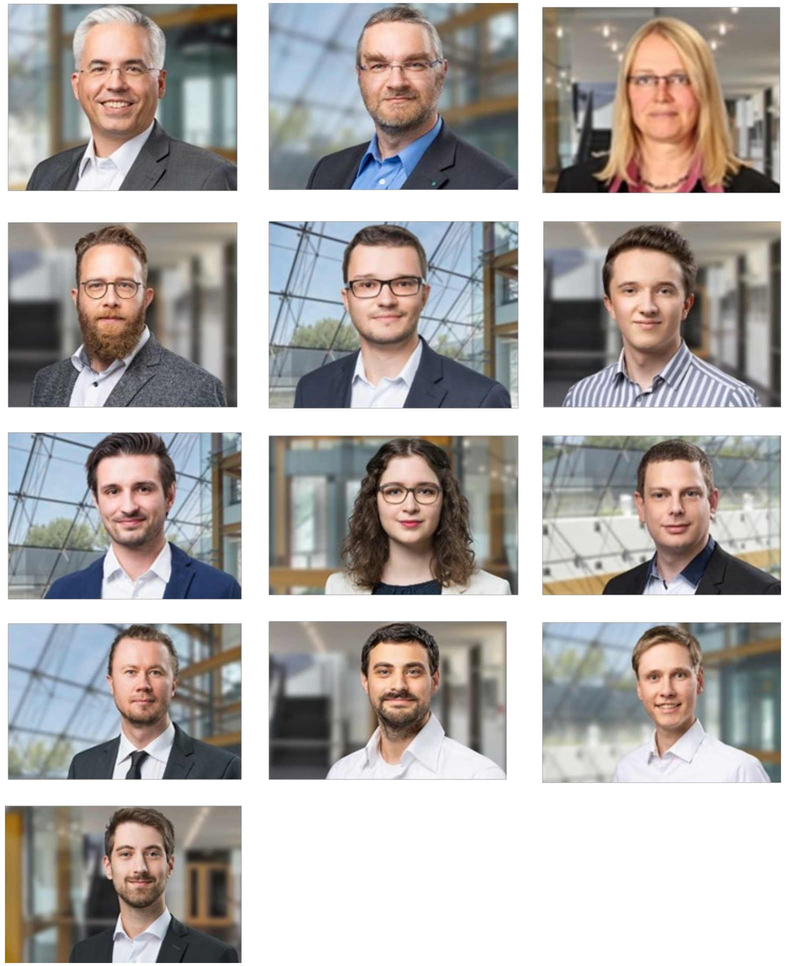
Fraunhofer IGD



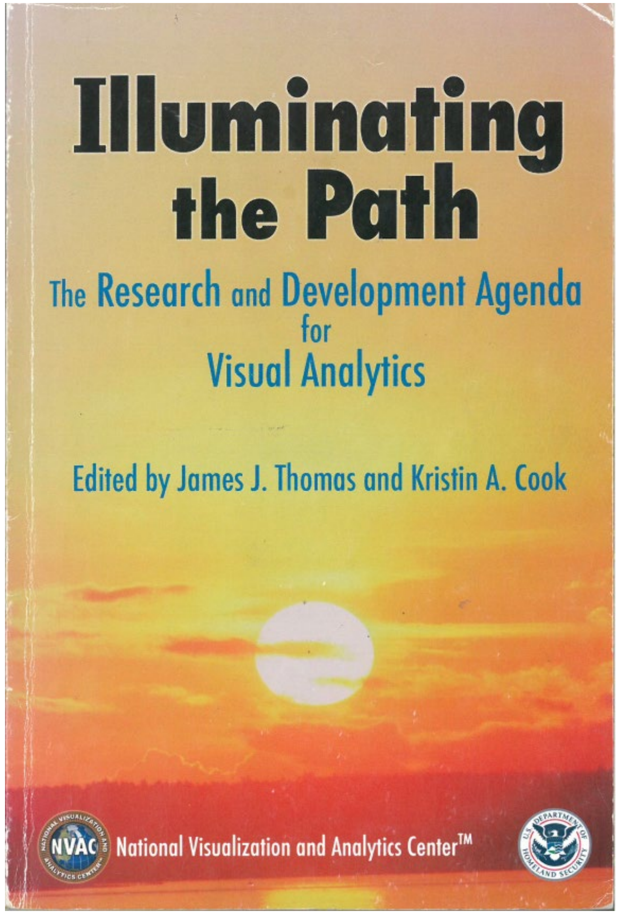
Fraunhofer IGD

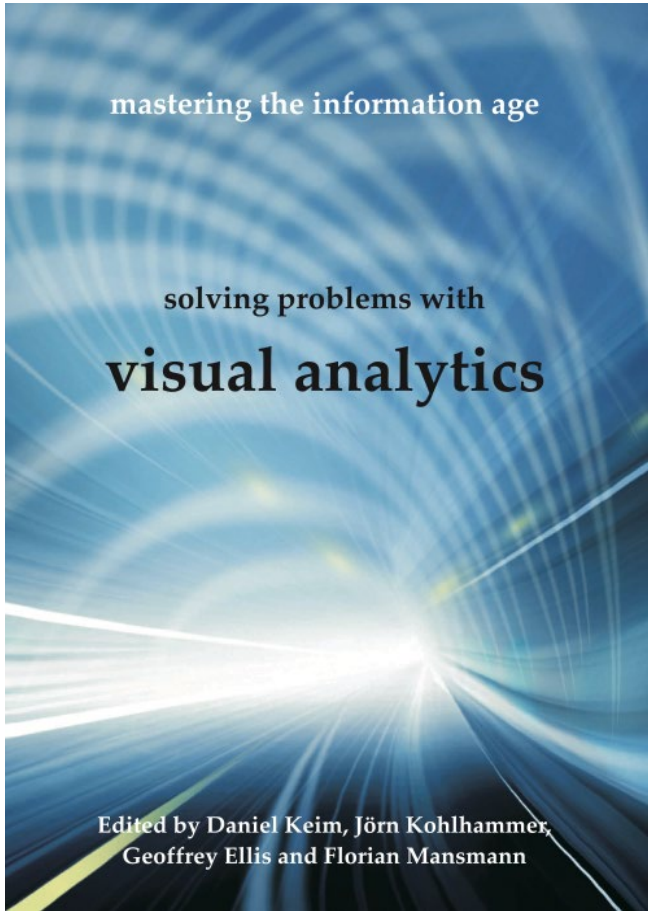
Intelligence
Graphics
Data

We live and shape visual computing

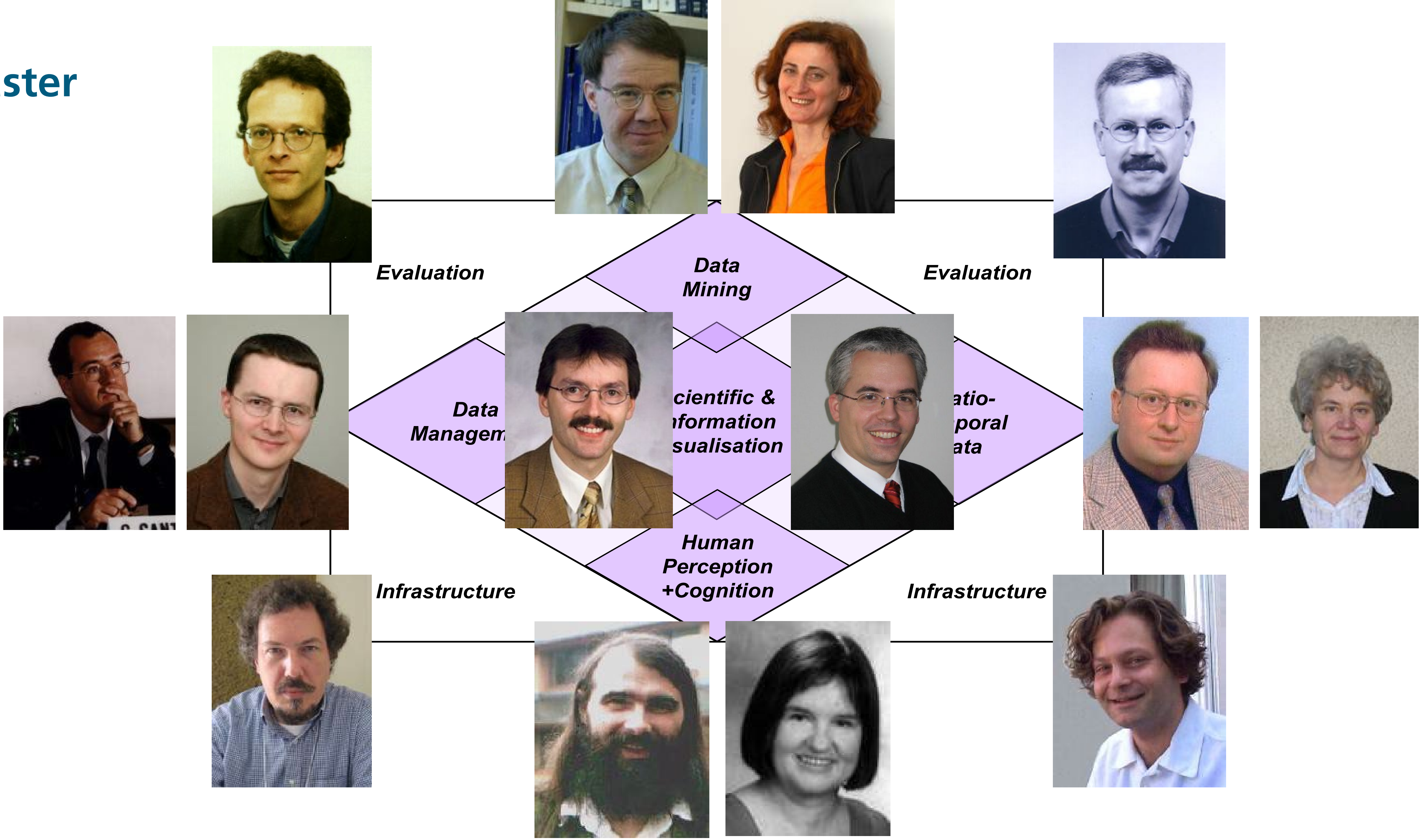
- Automotive Industry
- Healthcare
- Information Technology
- Maritime Economy
- Bioeconomy
- Cultural and Creative Economy

Visual Analytics in Europe





VisMaster



Evaluation
Data Mining
Evaluation
Data Managem
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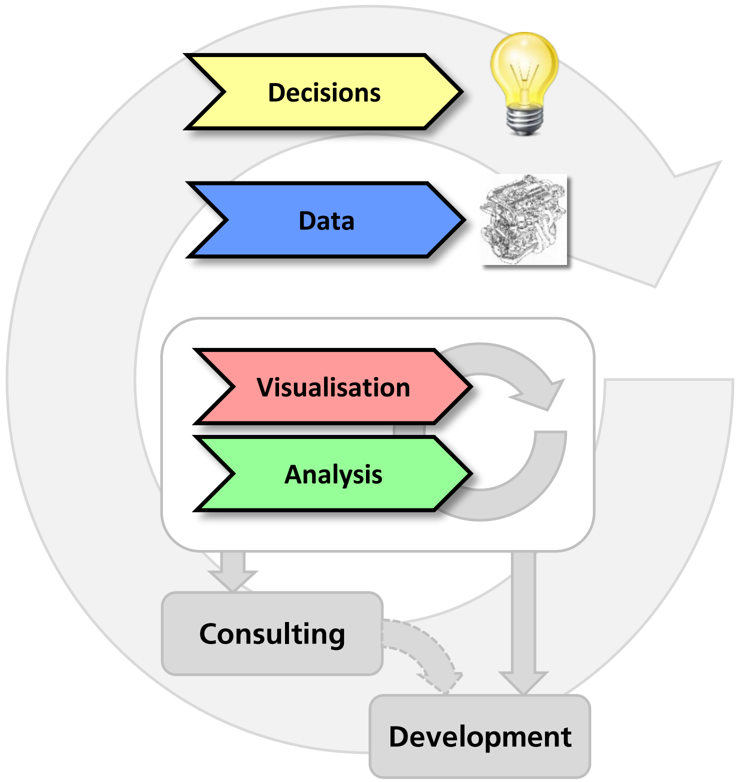
Infrastructure
Human Perception +Cognition
Infrastructure

Approach in Visual Analytics Projects

- User requirements
  (Relevant information, decisions, goals, etc.)
- Review of available data
  (Data types, schemes, relations, etc.)
- Iterative analysis and specification
- Choice and evaluation of visualizations and and modeling technologies
- Evaluation via end users
- Specification
- Implementation
- Final evaluation and deployment
- Support



Level of Automation

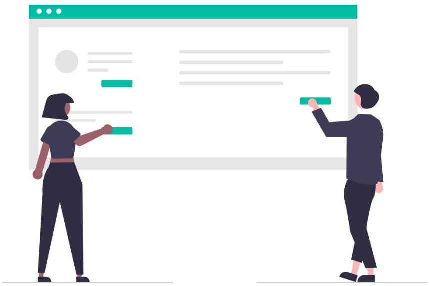
Human-in-the-loop

AI-in-the-loop

Level of Automation	Computer Autonomy	Human Authority	Adaptation
Supervisory Control	Full	Interrupt	Computer monitored by human
Direct Support	Action unless revoked	Revoking action	Computer assisted by human
In Support	Advice, if authorized, action	Accepting advice and authorizing action	Human assisted by computer
Advisory	Advice	Accepting advice	Human assisted by computer
At Call	Advice only if requested	Full	Human assisted when requested
Manual Control	None	Full	Human

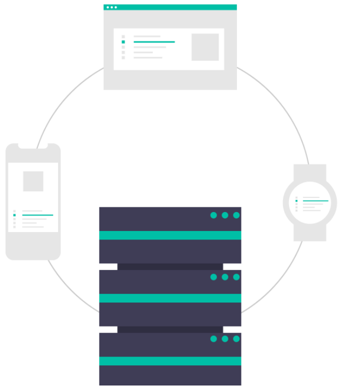
Kohlhammer, Decision-Centered Visualization, 2005

Division of labor between human and machine



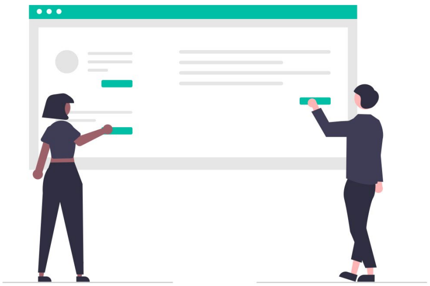
Manual Control

Strengths of humans	Strengths of systems
▪ Reaction to unusual and unexpected events ▪ Use of principles and strategies ▪ Situative adaption of decisions ▪ Experience-based actions ▪ Abduction from observations ▪ Development of new, unseen solutions	▪ Measurements and calculations ▪ Reliable storage of digital information ▪ Constant monitoring ▪ Data processing ▪ Rule-based actions ▪ Deterministic repetition of predefined actions ▪ Parallel processing of multiple actions



Full Automation

Division of labor between human and machine



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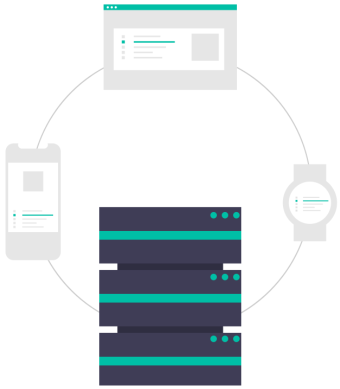


Full Automation

System advice on request

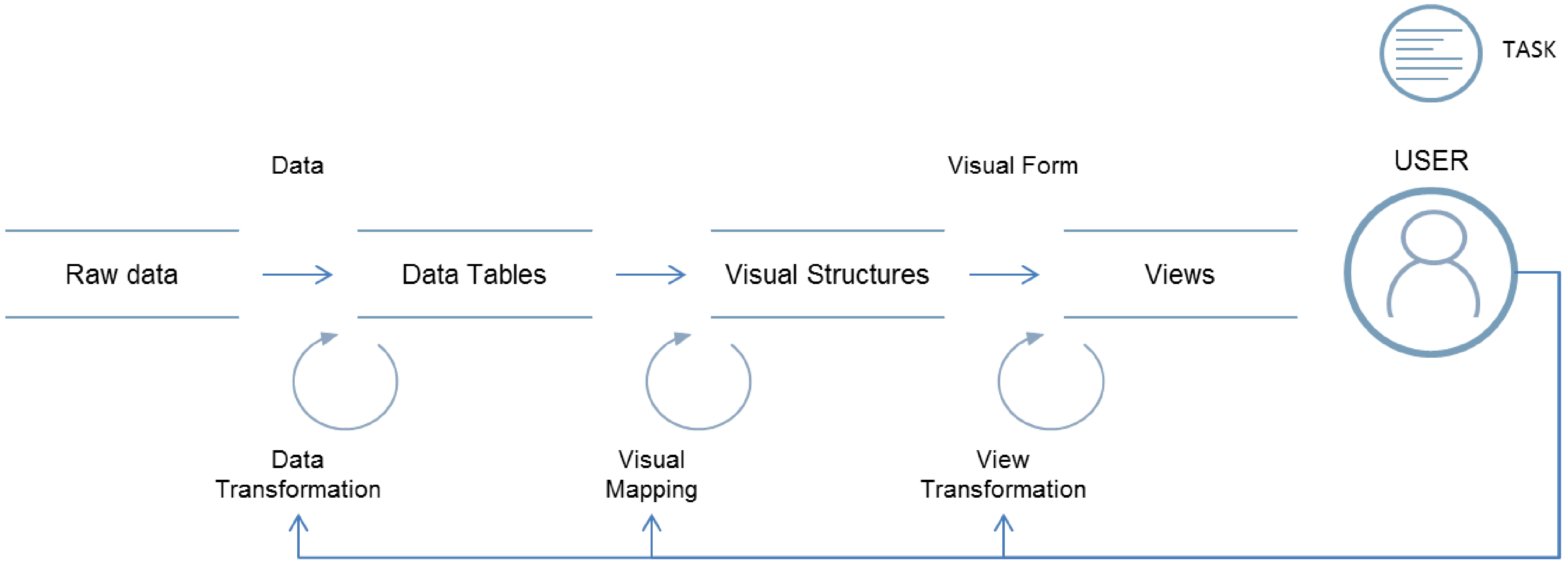
Recommender systems

Division of Labor

Human approval of actions

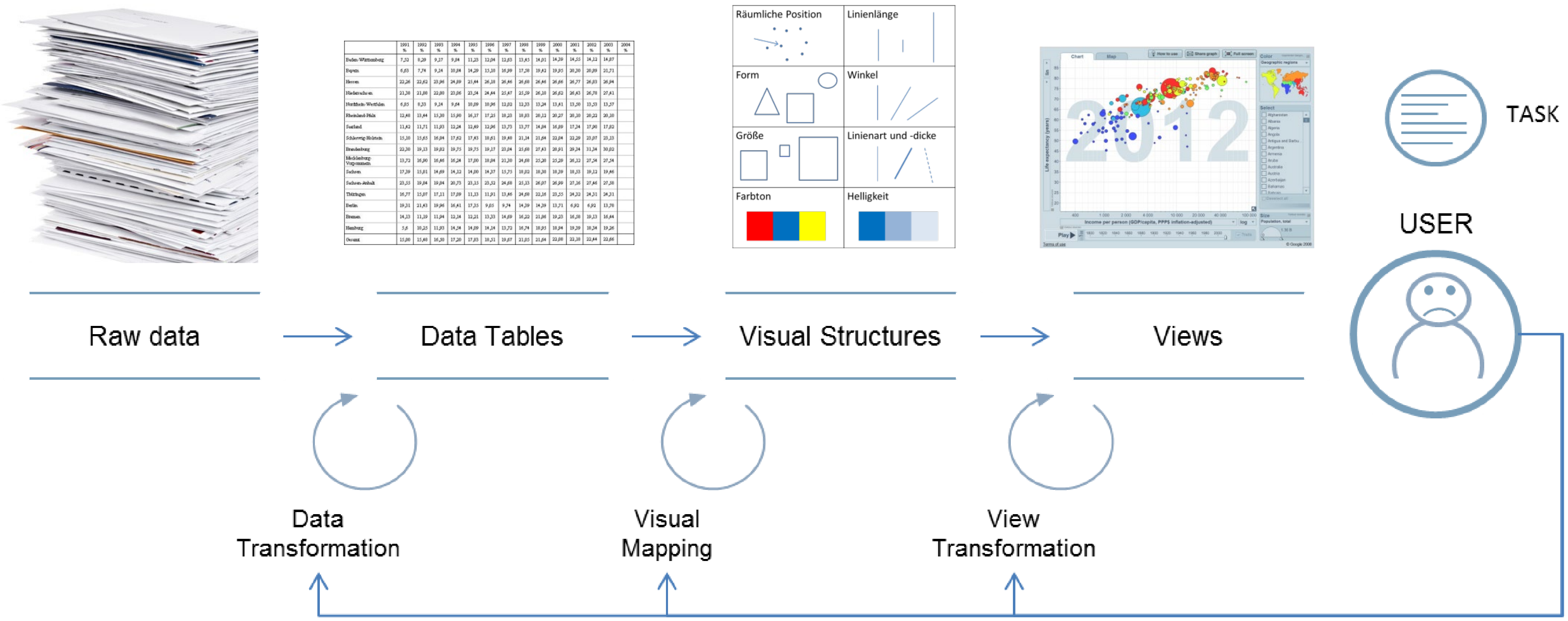
Monitor and interrupt

Information Visualization

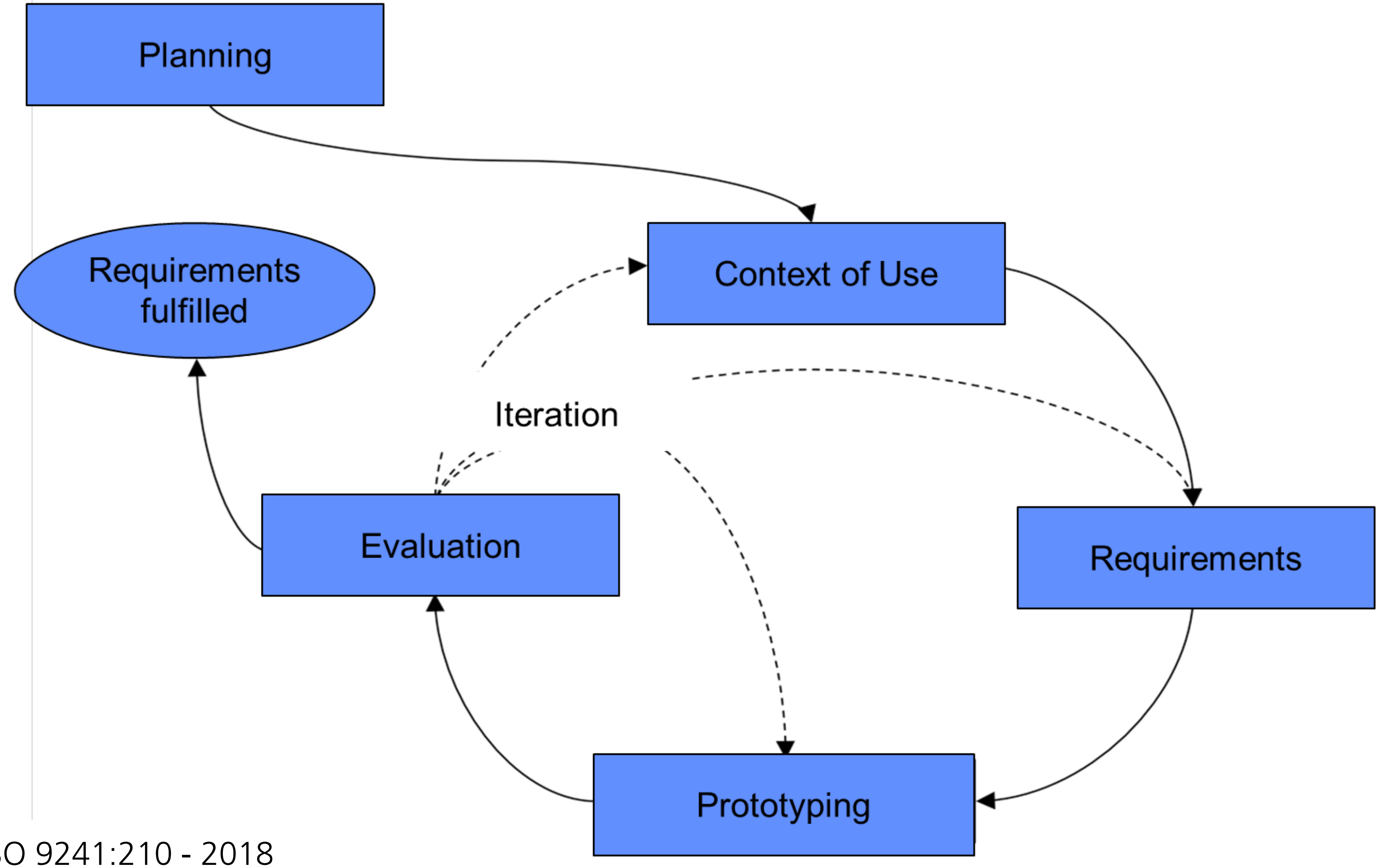


Adapted from Card et al. 1999

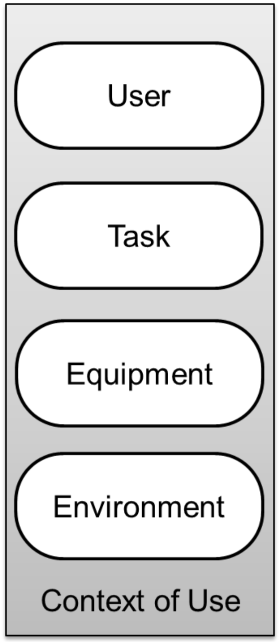
Information Visualization



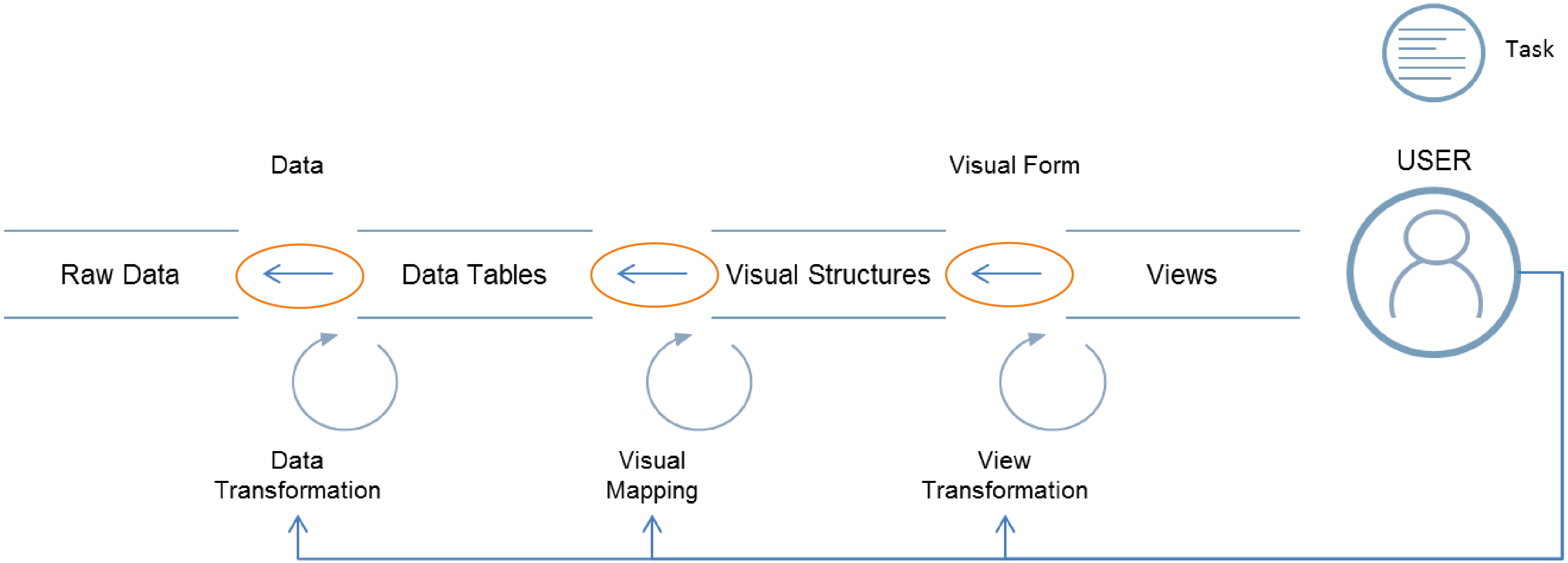
User-Centered Design



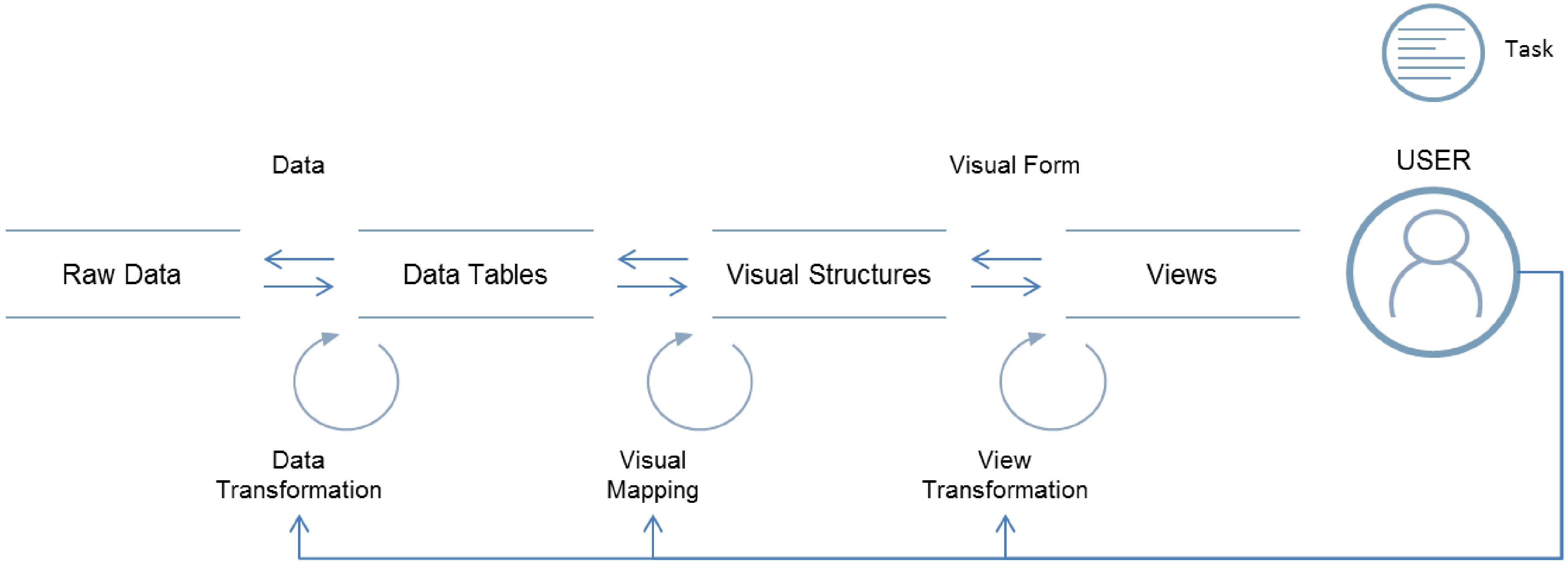
ISO 9241:210 - 2018



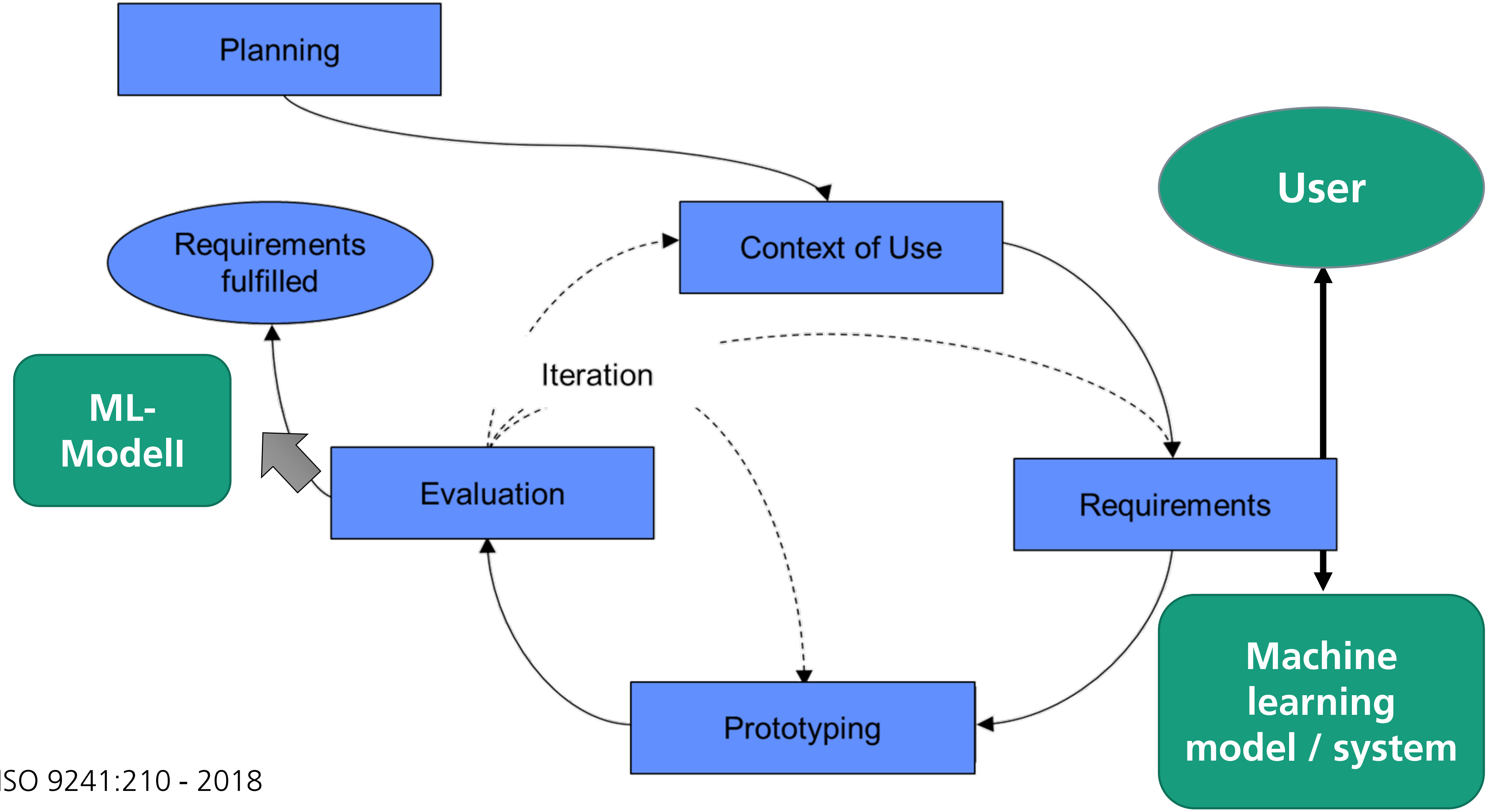
Implication of UCD



User-Centered Visualization

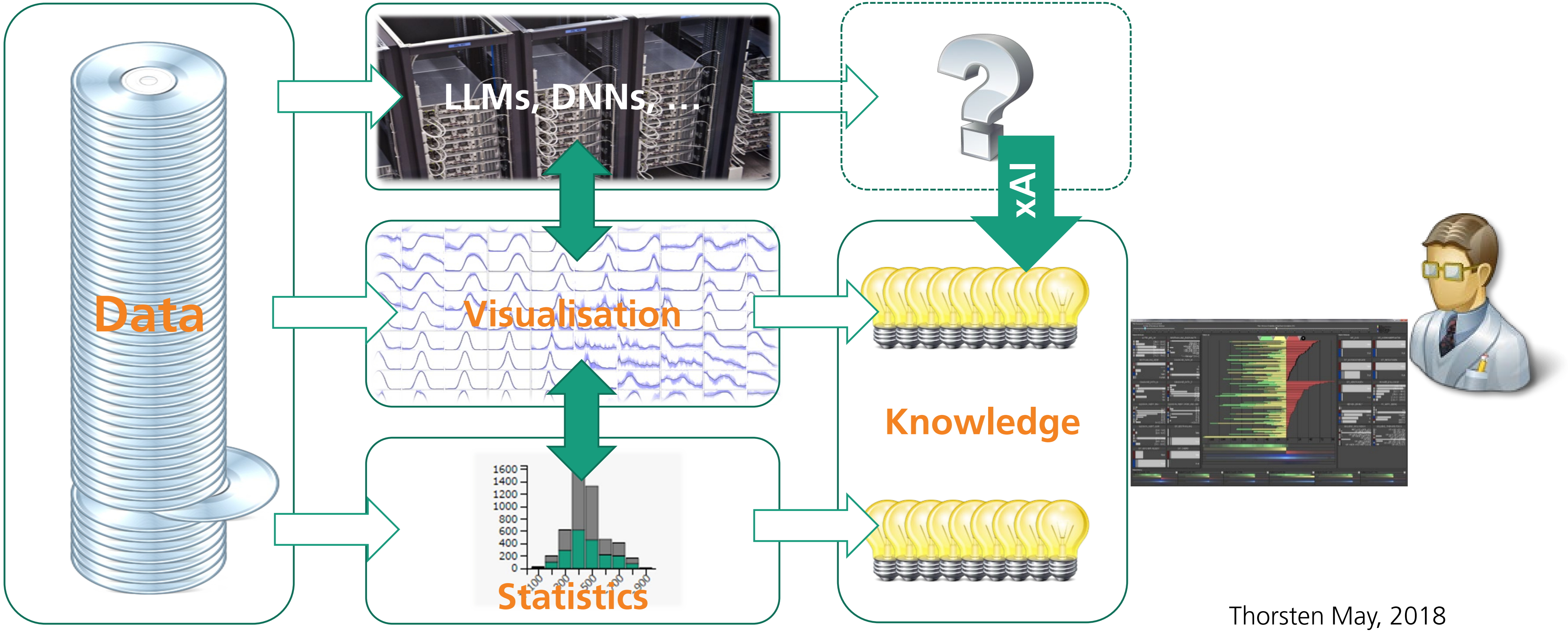


User-Centered Design with ML



ISO 9241:210 - 2018

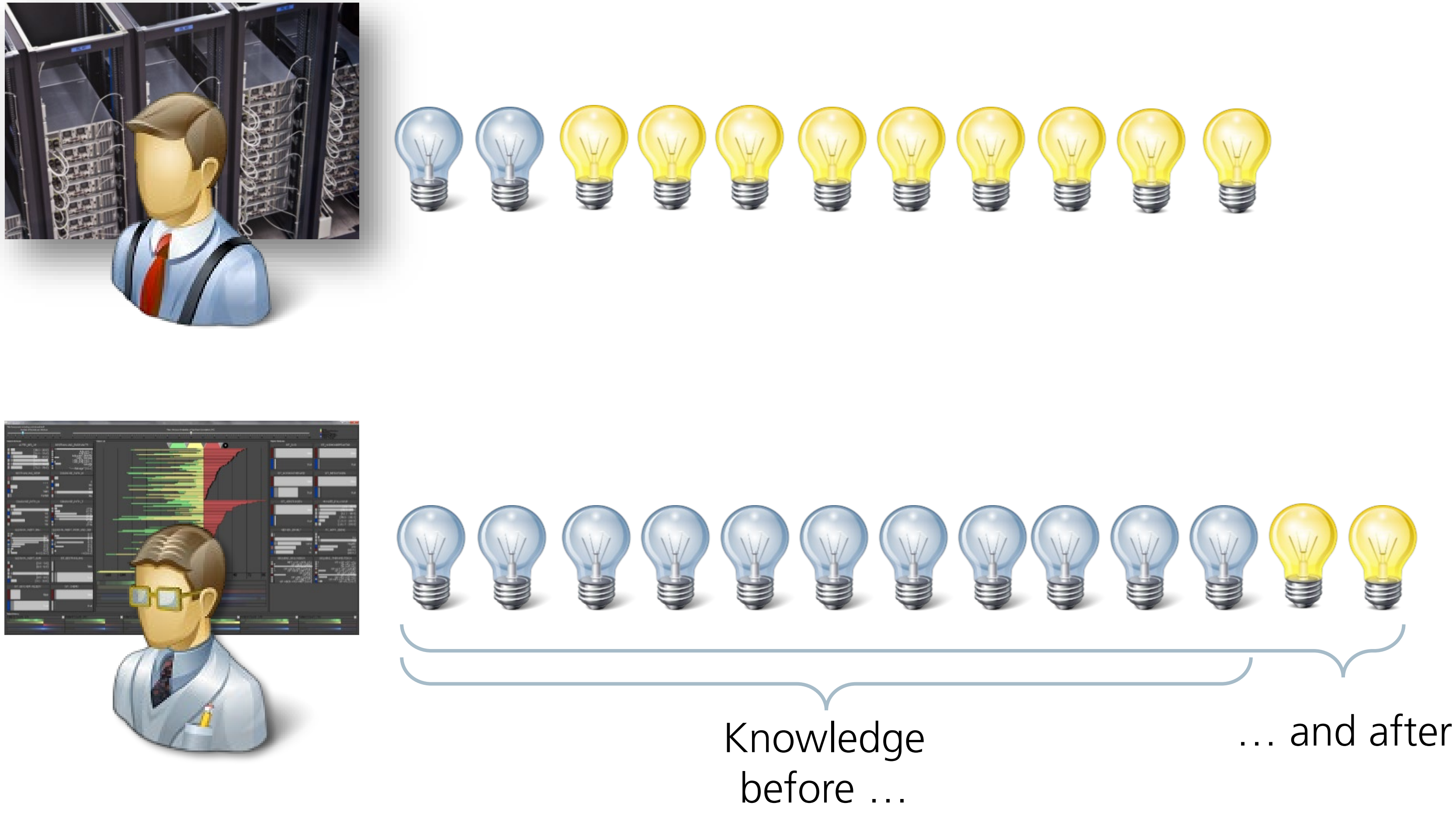
Intelligent Combination of Three Different Paths



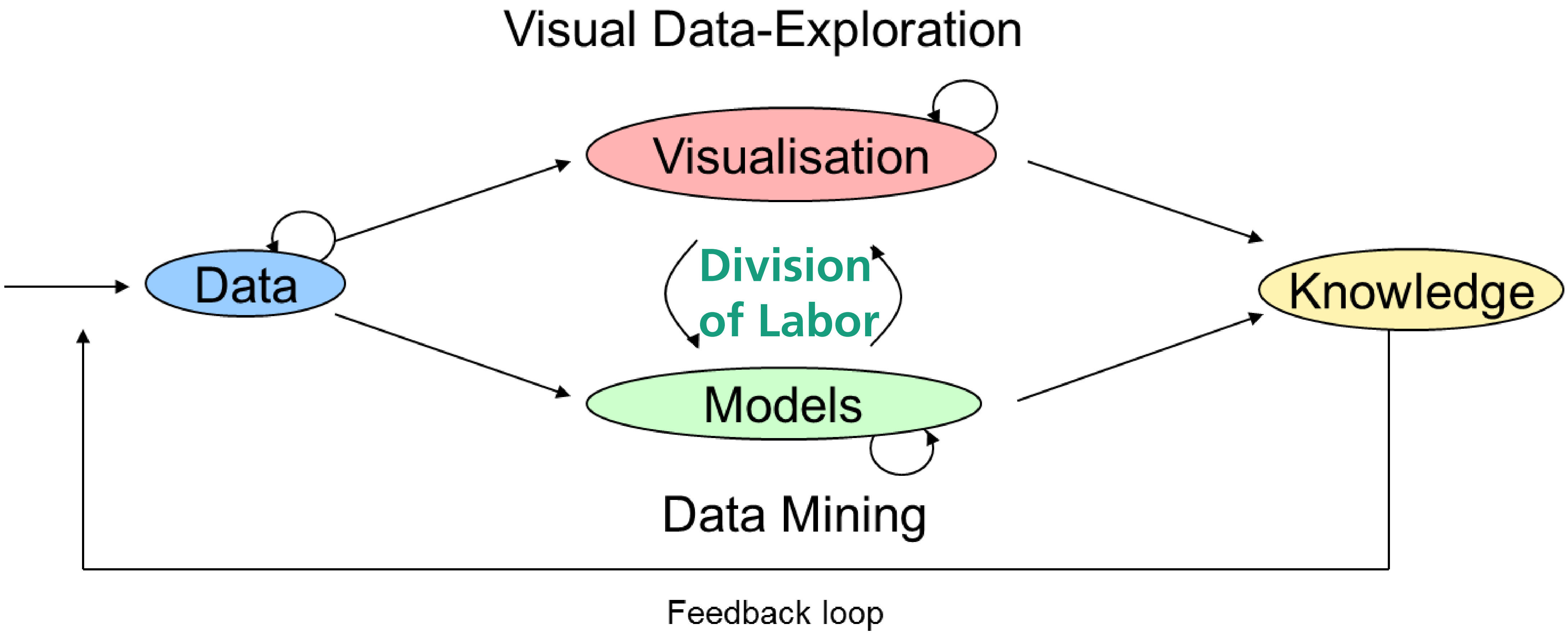
Thorsten May, 2018

Data-Driven Research…

Data-Driven Research…

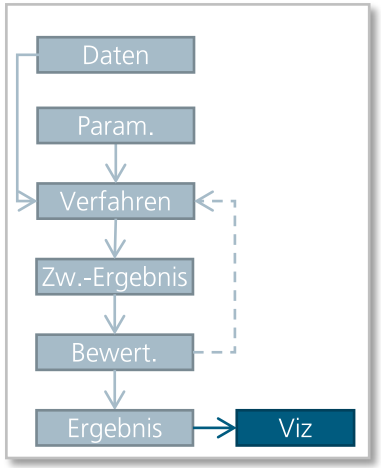


Visual Analytics



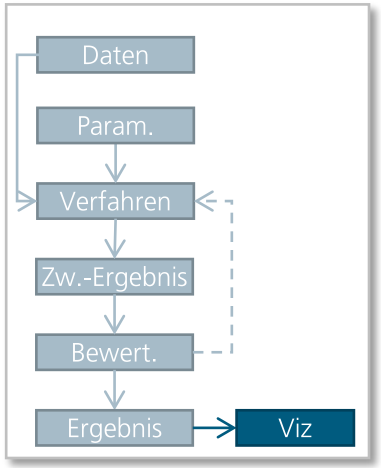
(Keim, 2008)

Overview of integration variants in visual analytics



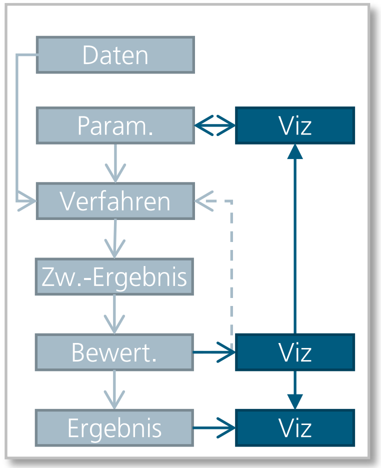
Model Presentation

Problem:
Results invisible
Goal:
Make results comprehensible



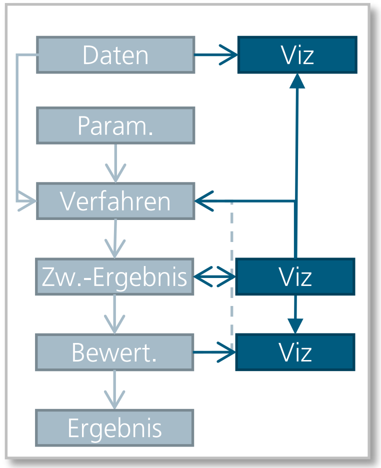
Pattern Exploration

Problem:
Assessment of patterns
Goal:
Detect commonalities and differences of patterns



„Black-Box-Integr.“

Problem:
Effects of parameters not predictable
Goal:
Efficiently test new parameters

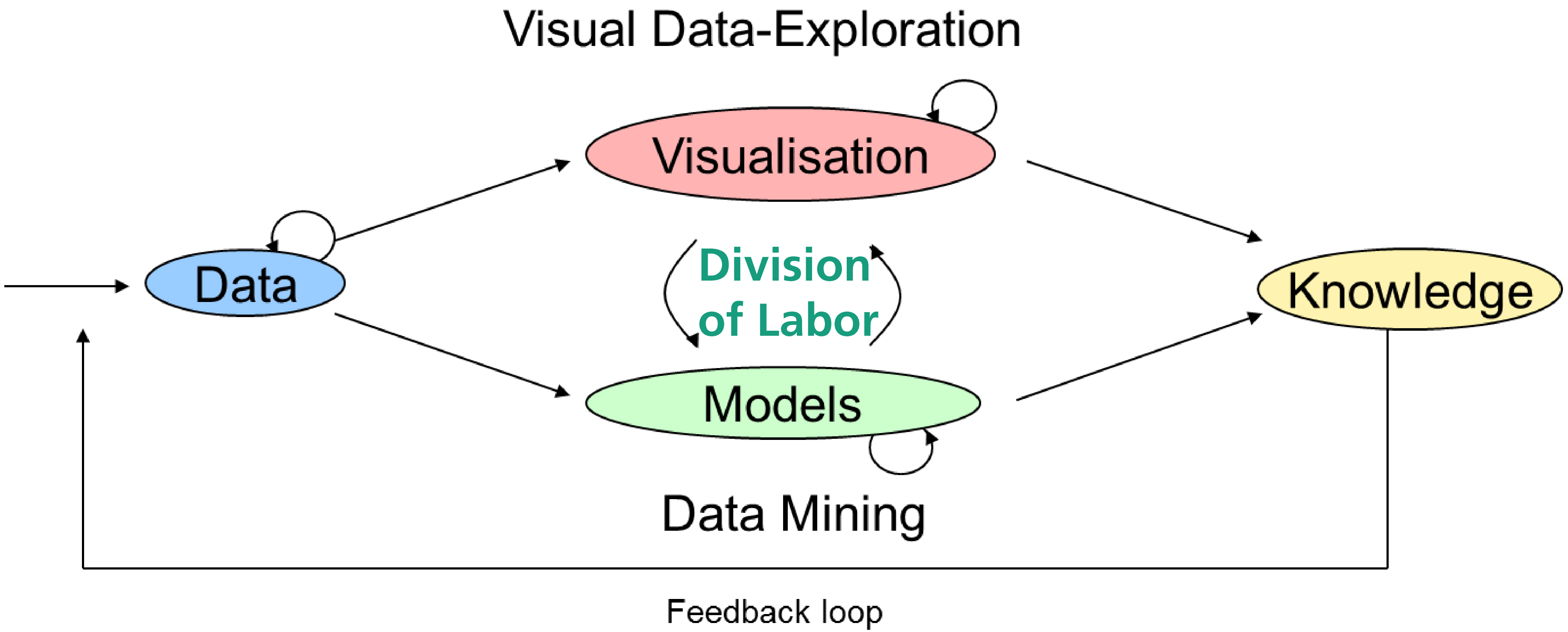


„White-Box-Integr.“

Problem:
Optimization is difficult
Goal:
Enhance optimization through human input

Inspired by Enrico Bertini and Denis Lalanne. 2010. Investigating and reflecting on the integration of automatic data analysis and visualization in knowledge discovery. SIGKDD Explor. Newsl. 11, 2 (December 2009), 9–18. https://doi.org/10.1145/1809400.1809404

Visual Analytics



(Keim, 2008)

User-Centered Visual Analytics

1. Understand your users, their data, and their tasks
2. Translate this to needs and requirements
3. a. Create solutions that automate the tasks to the required extent
   b. Combine the chosen automated methods with the most adequate visualization and explainability approaches (if needed)
4. Evaluate and iterate

Dagstuhl: The Role of Visualization in Fostering Trust in AI (2022)

1. Trust is not a technical problem.
2. Trust is dynamic.
3. Visualization cannot address all aspects of trust.
4. Visualization is crucial for human agency in AI.

(The Role of Interactive Visualization in Fostering Trust in AI
Emma Beauxis-Aussalet, Michael Behrisch, Rita Borgo, **Duen Horng Chau**, Christopher Collins, David Ebert, Mennatallah El-Assady, **Alex Endert**, **Daniel A Keim**, Jörn Kohlhammer, **Daniela Oelke**, Jaakko Peltonen, Maria Riveiro, Tobias Schreck, Hendrik Strobelt, Jarke J van Wijk, Theresa-Marie Rhyne, IEEE CG&A, 2022

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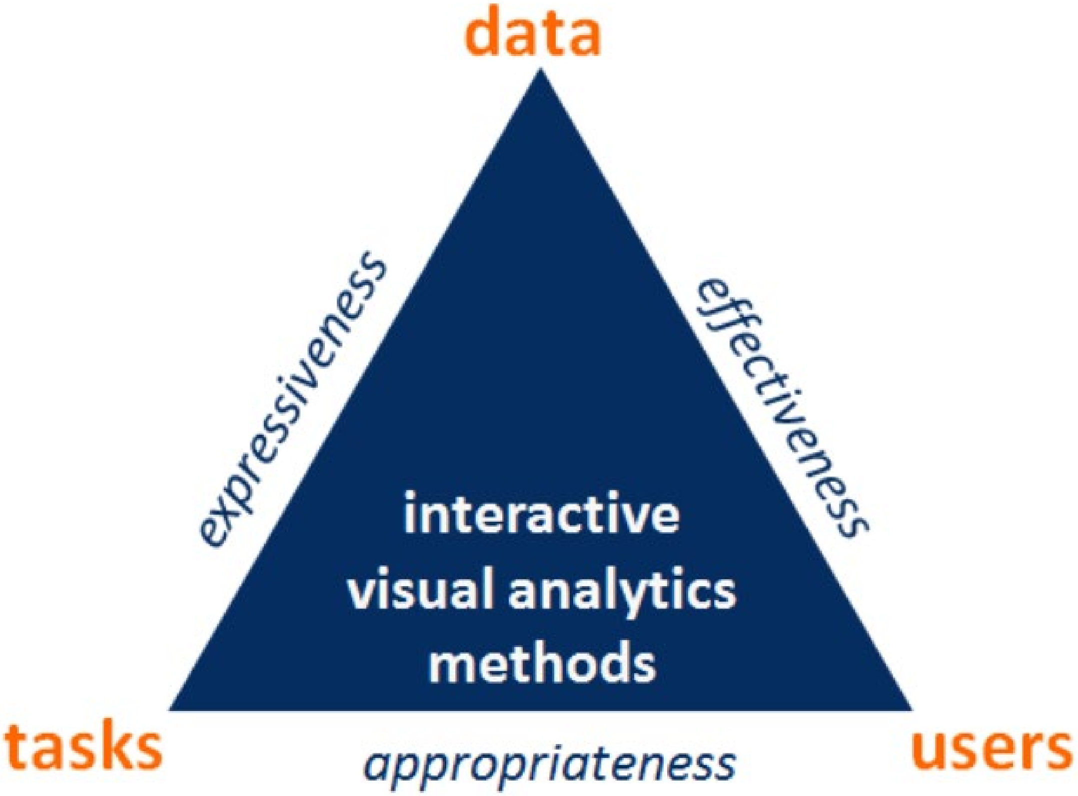
The Design Triangle



Miksch & Aigner (2014), *Applying a Data–Users–Tasks Design Triangle…, Computers&Graphics*

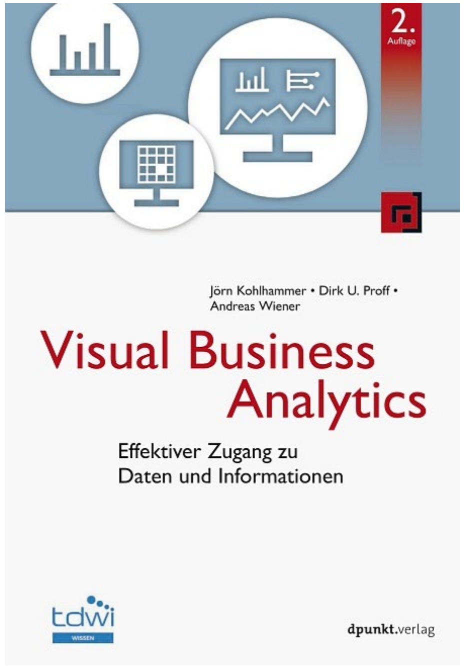
business | vis at IEEE VIS 2014 & 2015

many open challenges

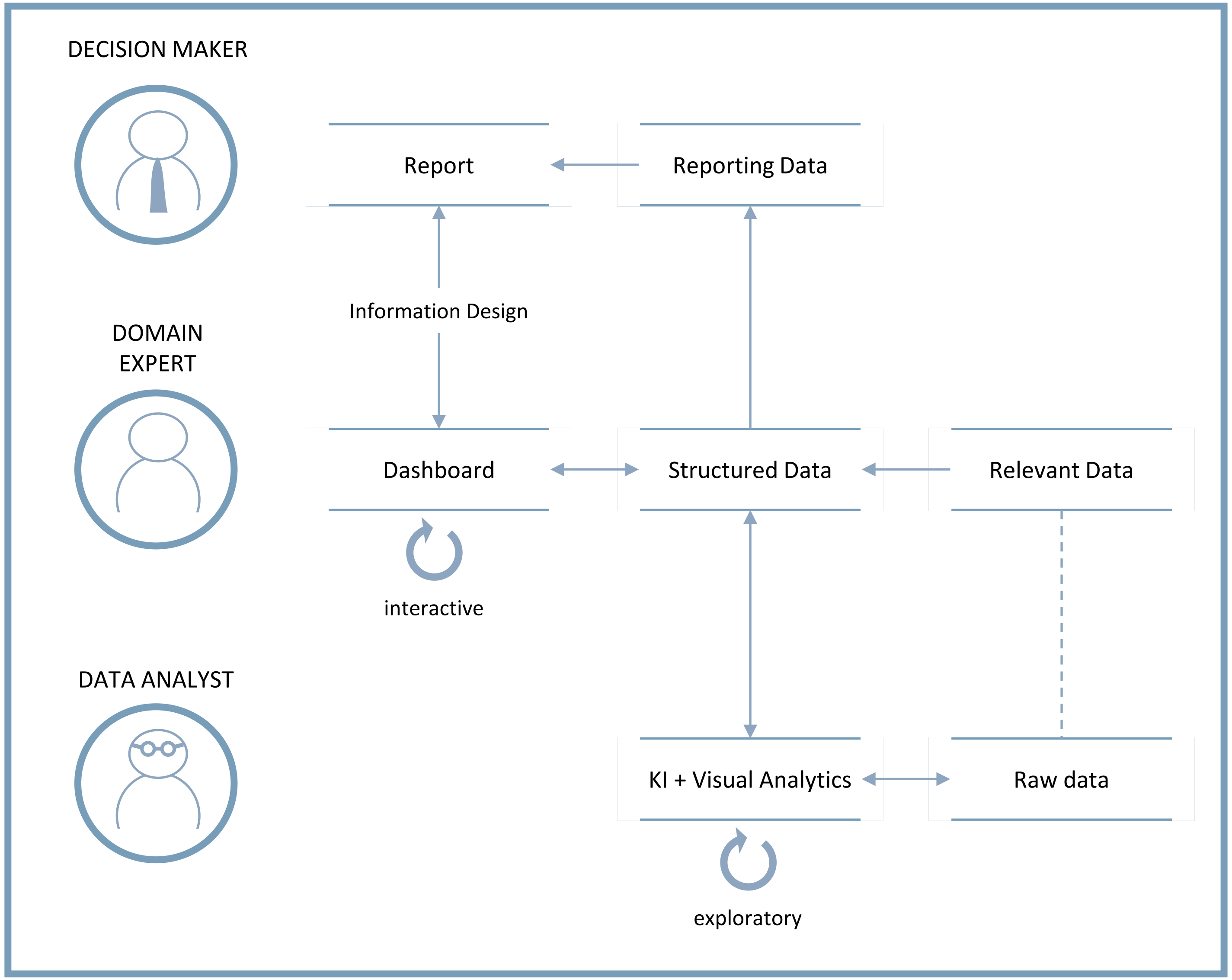
What is the value of vis?
How do you measure the value?
How do you evaluate vis in the wild?
What are the challenges of designing and implementing vis for business?
How do you get and manage data?
How do you design effective visualizations for non-technologists?
How do you move beyond “dashboard” visualization?
How do you create strategic visualization tools?
What role do visualizations play in the strategic planning process?
…

Organizers: Rahul Basole, Steven Drucker, Jörn Kohlhammer, Jarke van Wijk

Users

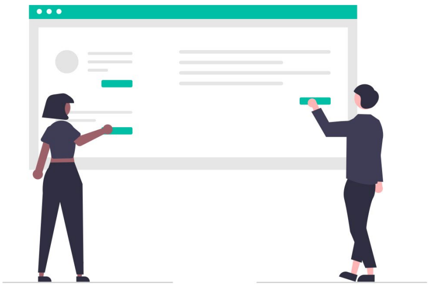


2.
Auflage
Jörn Kohlhammer • Dirk U. Proff •
Andreas Wiener
Visual Business Analytics
Effektiver Zugang zu
Daten und Informationen
tdwi
dpunkt.verlag



DECISION MAKER
DOMAIN EXPERT
DATA ANALYST
Report
Reporting Data
Information Design
Dashboard
Structured Data
Relevant Data
interactive
KI + Visual Analytics
Raw data
exploratory

Division of labor between human and machine



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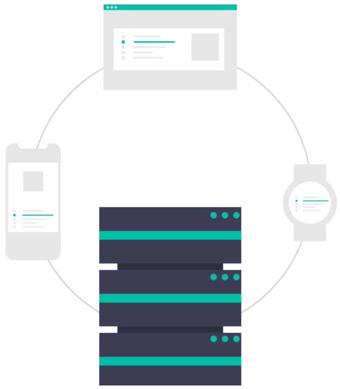


Full Automation

System advice on request

Recommender systems

Division of Labor

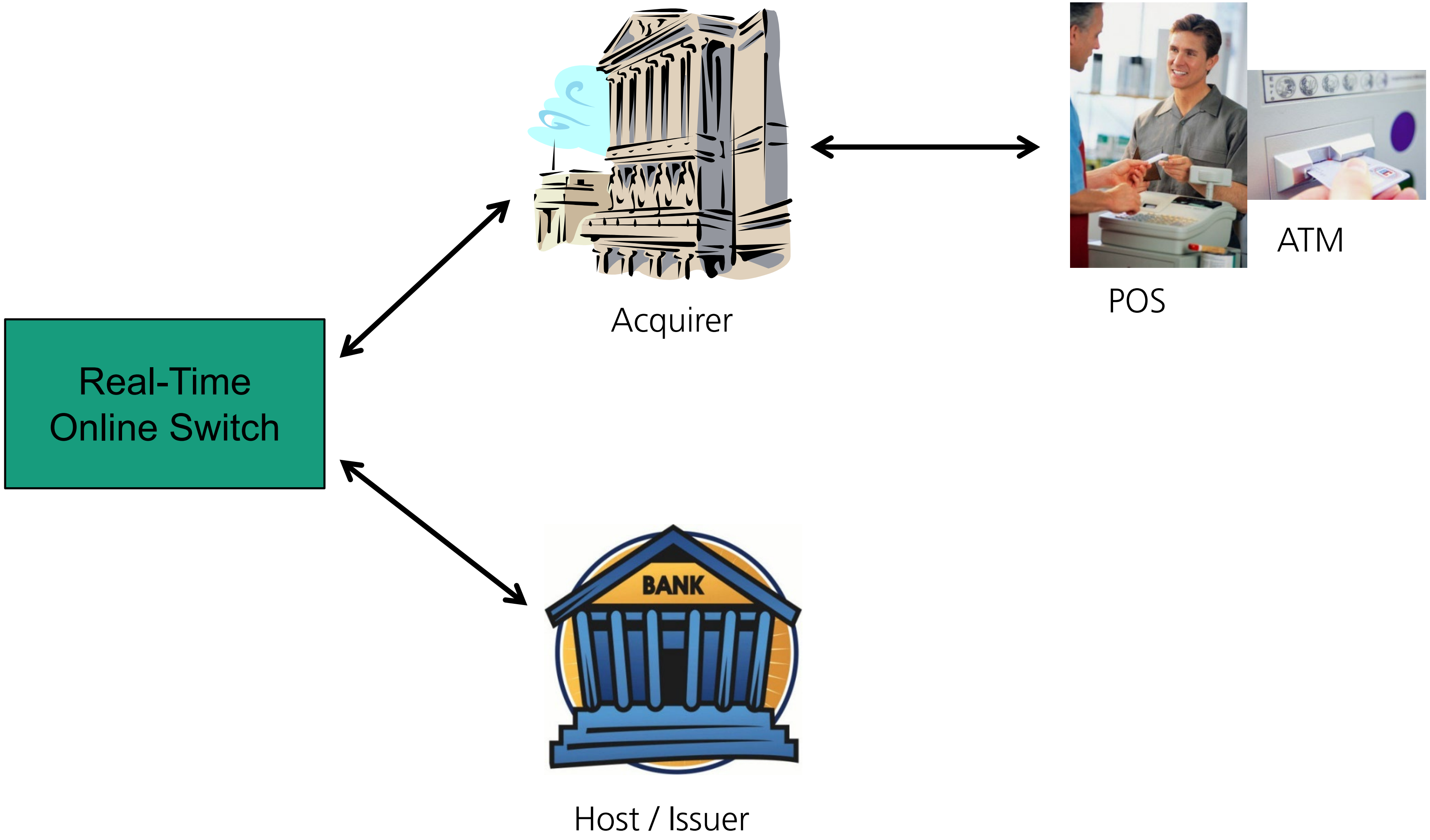
Human approval of actions

Monitor and interrupt

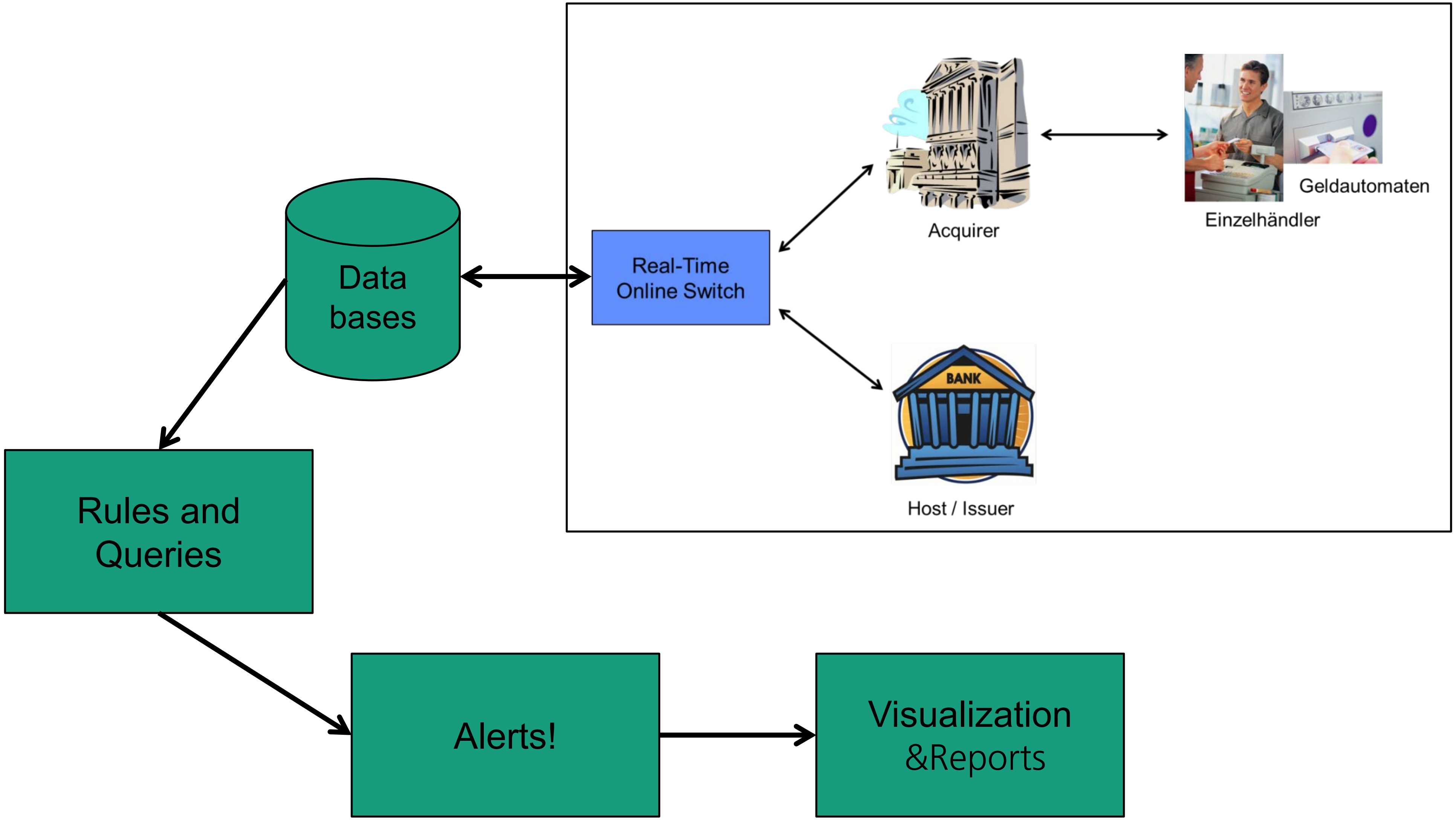
Three Use Cases

- Fraud Detection: Manual finetuning of models
- Cyber Security: Network analysis
- Medicine: Model steering in nephrology and CKD

Fraud Detection



Fraud Detection



Fraud Detection

50 and more attributes

Amount	Merchant#	Location	Local Trans-action Time	Country Code	POS PAN	MCC	Expiry Date	...	Card#

e.g. over 20 bill. VISA card transactions per year

↓

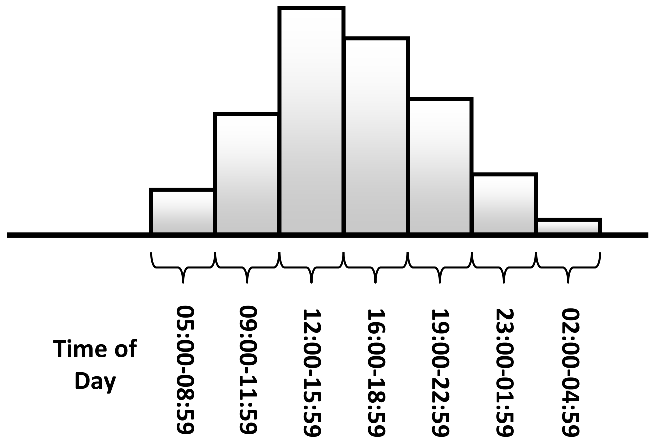
Problem: Fixed rules only find known fraud schemes

Schemes change so quickly that you cannot easily train AI methods

High value of human intelligence and experience

How to quickly find new fraud schemes?

Histogramm für ein Attribut

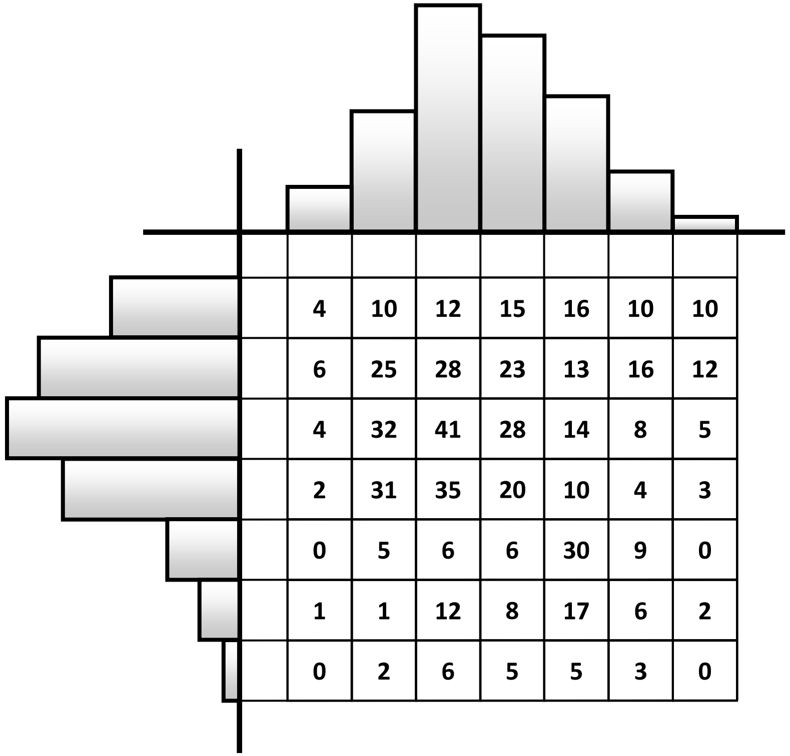


Beispiel:

Zeit der Kreditkarten-transaktion

1-dimensionales Histogramm

Histogramme und Tabelle für zwei Attribute



-$9	4	10	12	15	16	10	10
$10-$99	6	25	28	23	13	16	12
$100-$299	4	32	41	28	14	8	5
$300-$499	2	31	35	20	10	4	3
$500-$699	0	5	6	6	30	9	0
$700-$999	1	1	12	8	17	6	2
$1000-	0	2	6	5	5	3	0

Beispiel:
Zeit der Transaktion abgebildet auf Zahlungsbetrag

Zwei 1-dimensionale Verteilungen kombiniert in einer Tabelle

(Zahlen stehen für die Größe der verschiedenen Gruppen)

Mustererkennung

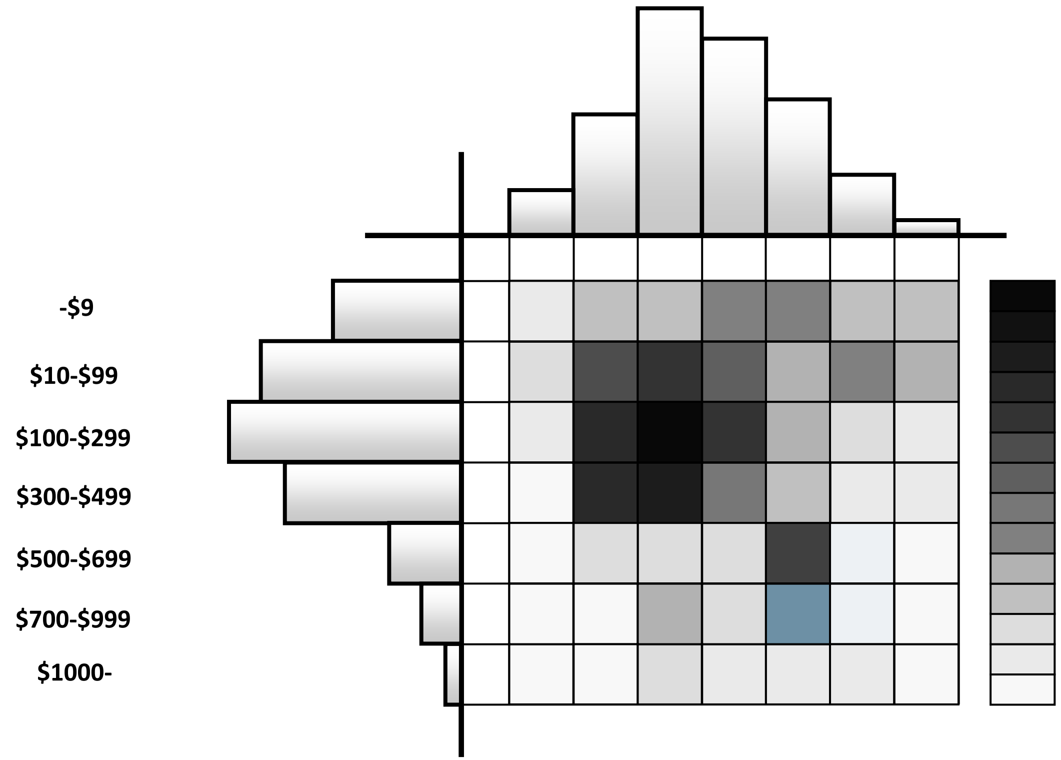
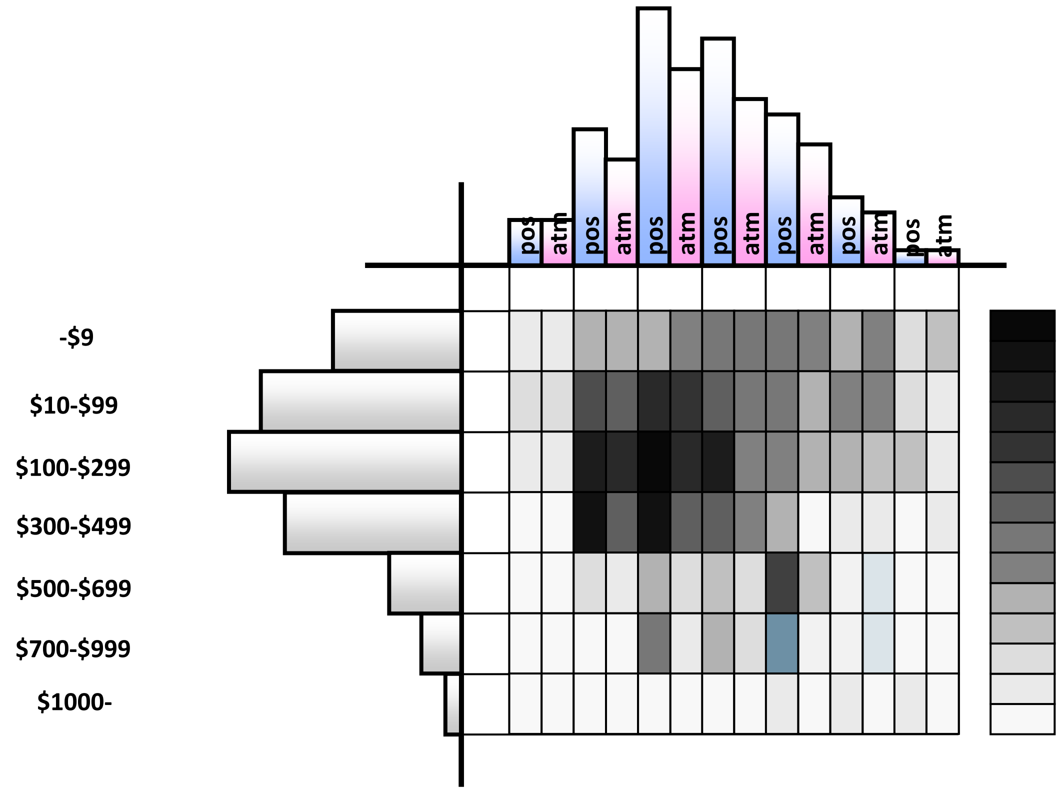


Abbildung der Gruppen-größe auf Helligkeit

Interessante Bereiche können „auf einen Blick“ erkannt werden.

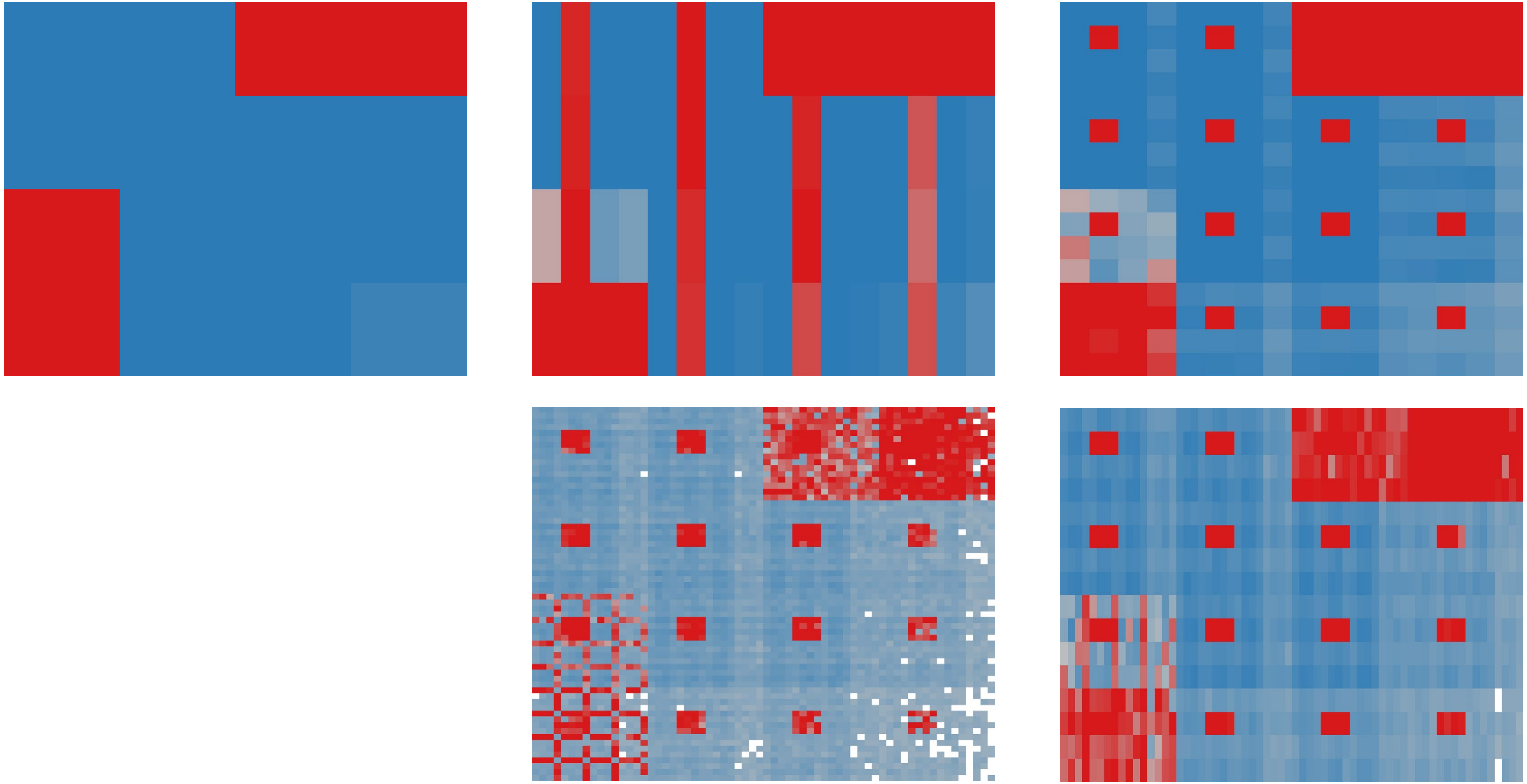
Herausforderung: Sehr viele Attribute



Verwobene Darstellung von drei (und mehr) Attributen

Hier zusätzliches Attribut: POS oder ATM

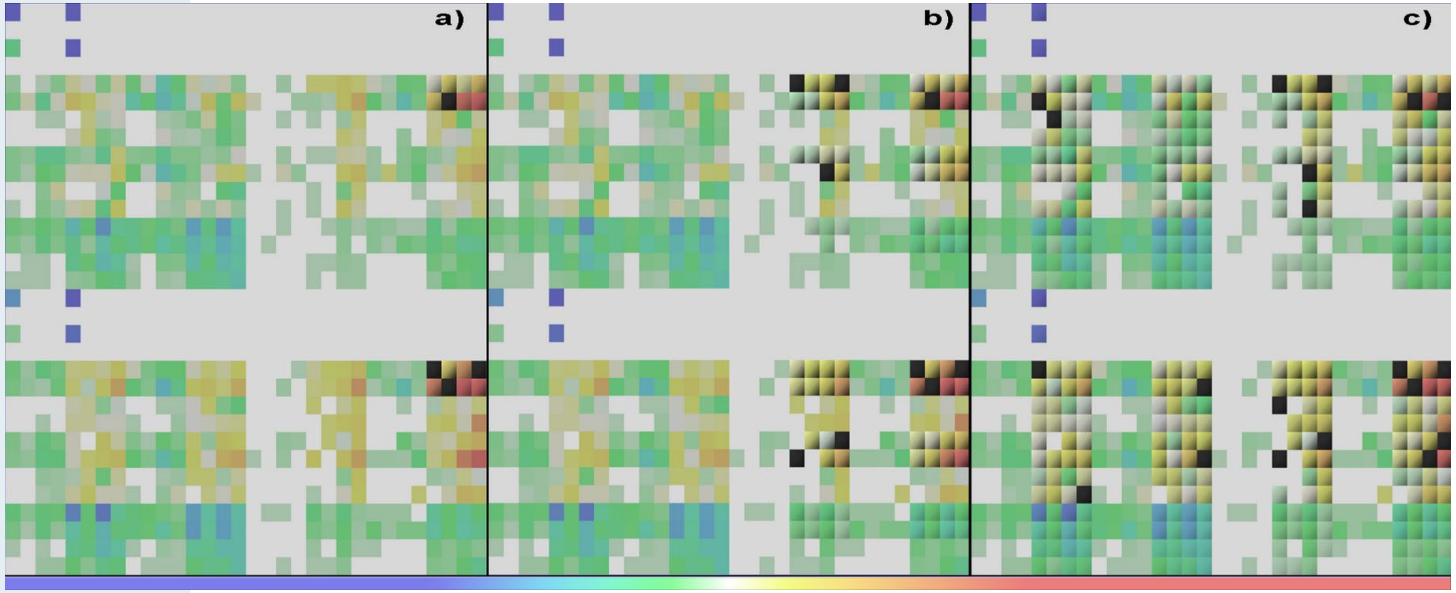
Example: Large training sets with 6 dimensions



Fraud Detection

Amount	Merchant#	Location	Local Trans-action Time	Country Code	POS PAN	MCC	Expiry Date	…	Card#

- Visual detection of relationships
- Experts at the center of the analysis
- Identification of interesting patterns in large data sources
- Dynamic sales and transaction data
- Data-driven fraud detection
- Interactive fine-tuning and (post) training of AI models

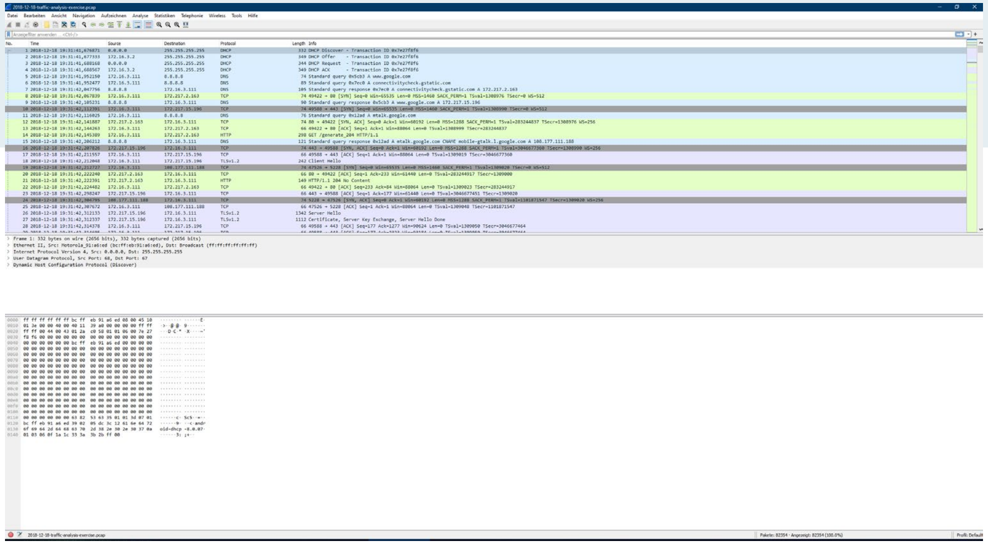


Visual Analytics for forensics and monitoring in cybersecurity

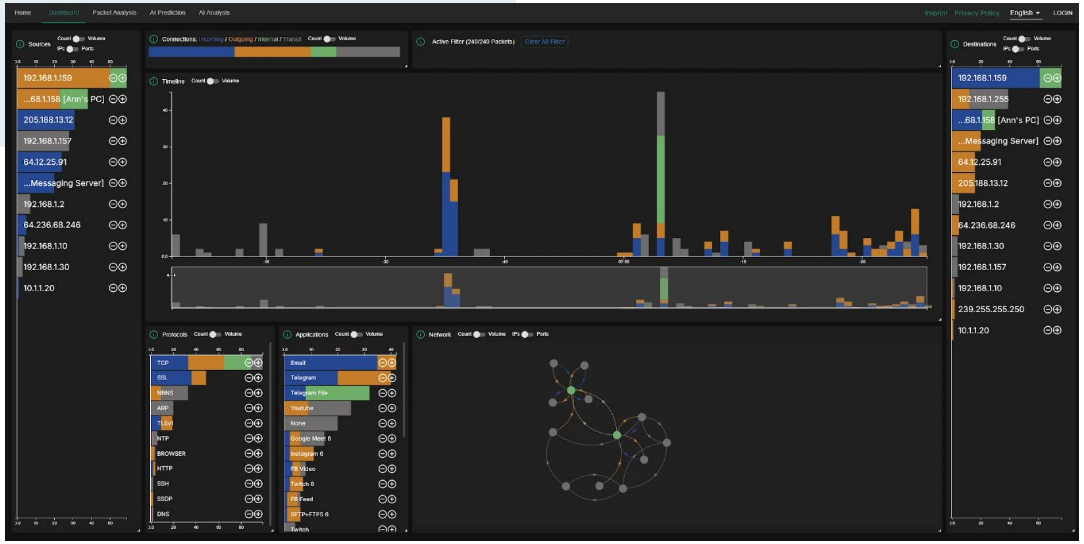
- Fast detection of new, previously undetected vulnerabilities and attack patterns
- Processing and analysis of large data sets
- Typical needle-in-a-haystack problem
  - Difficult to automate
  - High rate of false positives
  - Tedious human tasks and high error rates
- Tools like Wireshark mostly console-based
- Our approach: Interactive handling of network data and anomalies
- Fast resolution of potential problems

NetCapVis – Visual analysis of network packet captures (pcaps)

- Find relevant traffic in pcap data faster
- Visually enhancing work with tools like Wireshark
- Interactively work with AI results and visualizations in context
- Try it out at: https://netcapvis.igd.fraunhofer.de/



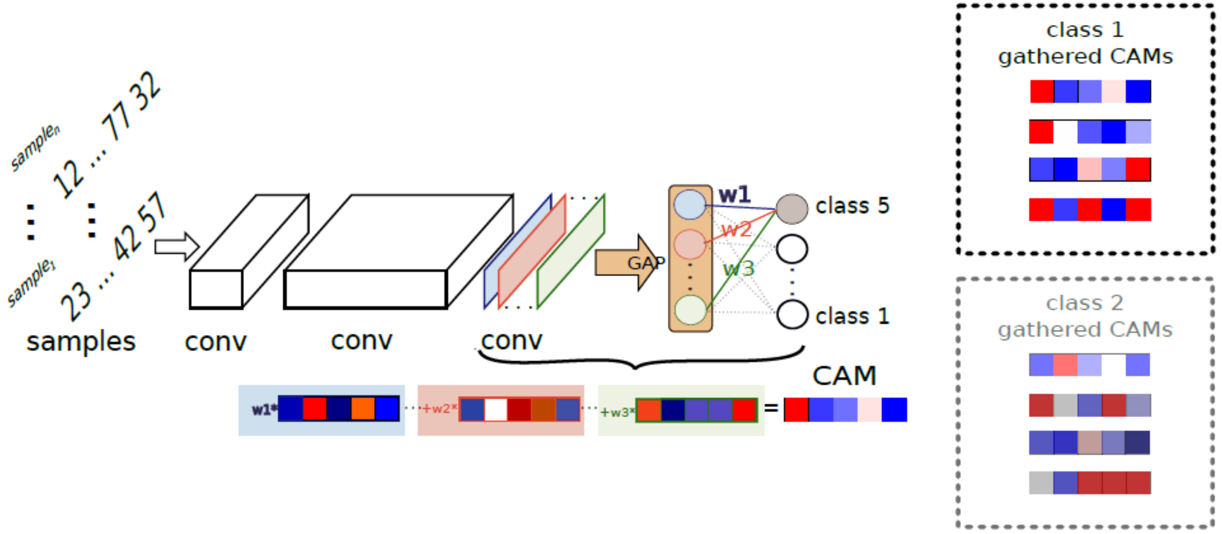
Wireshark

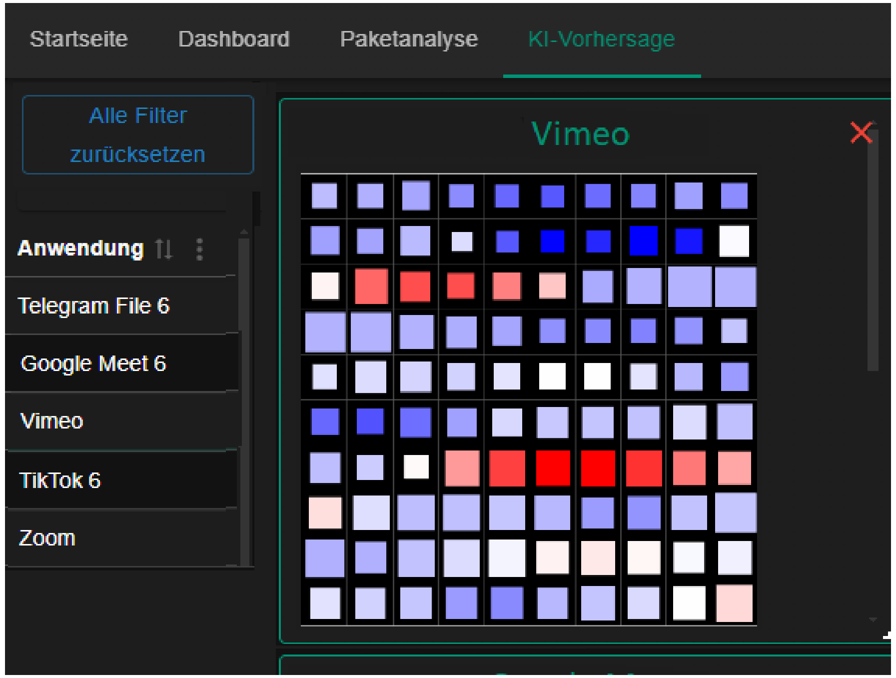


NetCapVis

NetCapVis – Visuelle Analyse mit KI-basierter Packet Source-Erkennung

Visualization of Aggregated Class Activation Maps





Cherepanov, I., Sessler, D., Ulmer, A., Lücke-Tieke, H., Kohlhammer, J. (2023). Towards the Visualization of Aggregated Class Activation Maps to Analyse the Global Contribution of Class Features. In: Longo, L. (eds) Explainable Artificial Intelligence. xAI 2023

Medical User Groups

Clinical study physicians

Analysts for research purposes

Discovery of new biomarkers

Hypothesis generation

Data consolidation & visual overview

High-quality medical reports

Cohort creation and analysis

Laboratory analysts

Practicing physicians

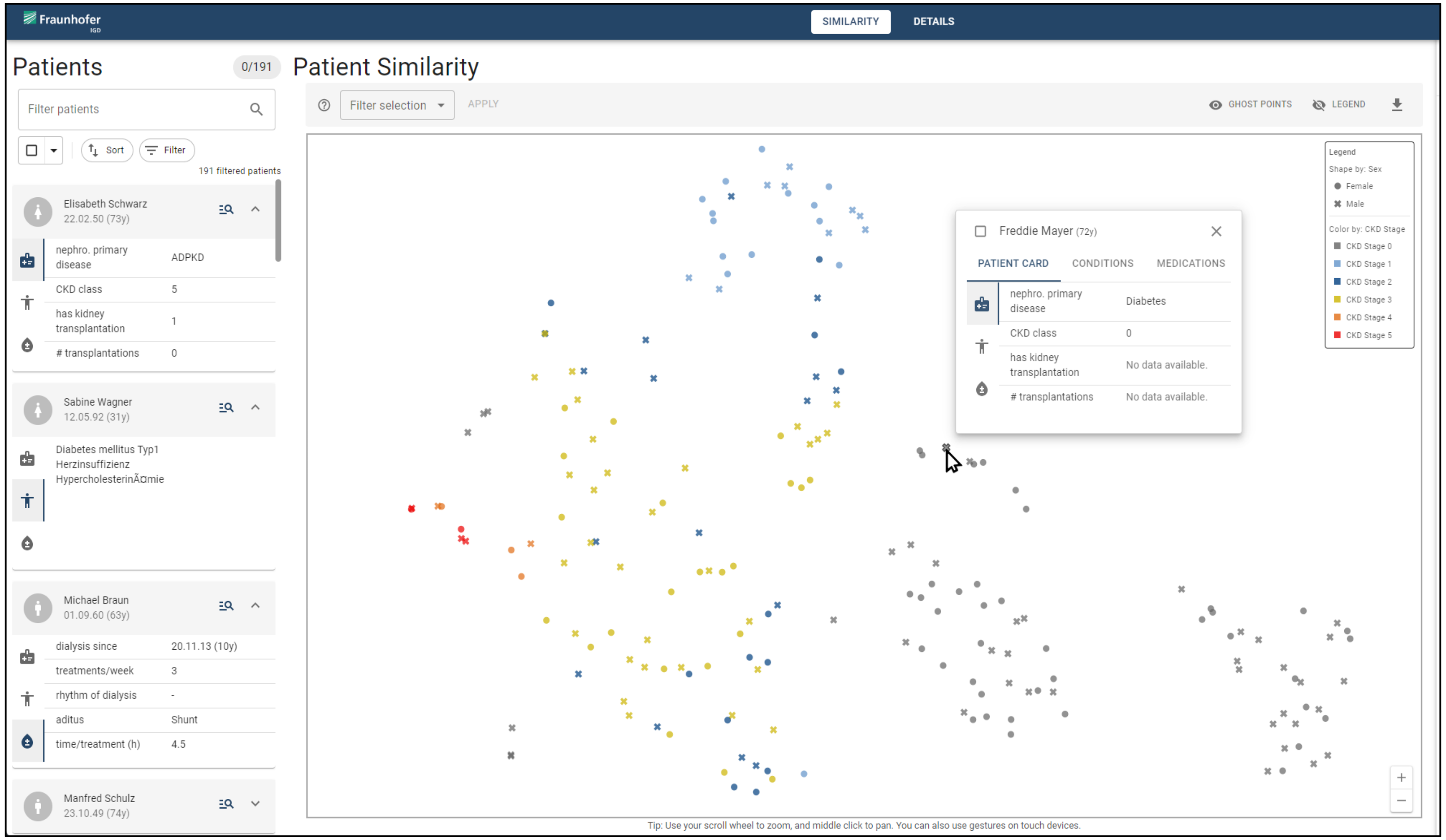
  Offen

IGD-Folienvorlage-de.potx, Version 3.2, 31.03.2022

Fraunhofer IGD

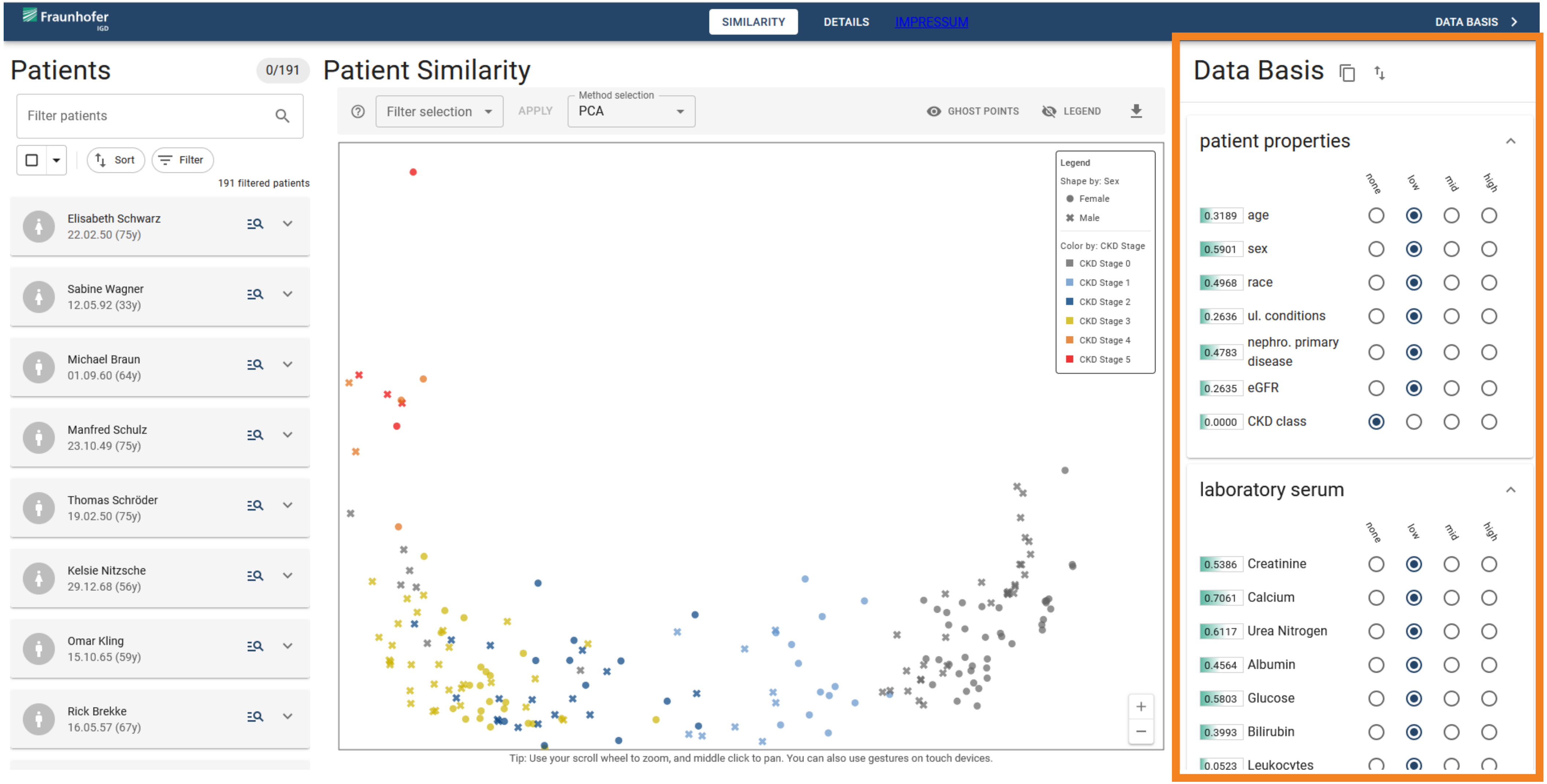
Enhancing cohort models in nephrology

- 191 (real and synthetic) patients
- Interactive filters
- Exploration of various parameters at a glance
- Interactive similarity definition in collaboration with medical experts

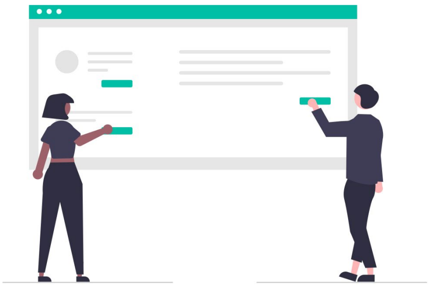


Markus Höhn, Sarah Schwindt-Drews, Sara Hahn, Sammy Patyna, Stefan Büttner, Jörn Kohlhammer, RenalViz::Visual analysis of cohorts with chronic kidney disease, Computers & Graphics, Volume 125, 2024, https://doi.org/10.1016/j.cag.2024.104120.

Enhancing cohort models in nephrology



Division of labor between human and machine



Manual Control

System advice on request

Modeling in Fraud Detection Systems

Recommender systems

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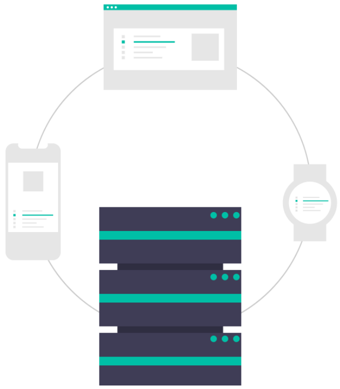
Division of Labor

PCAP analyses with AI-driven source detection



Full Automation

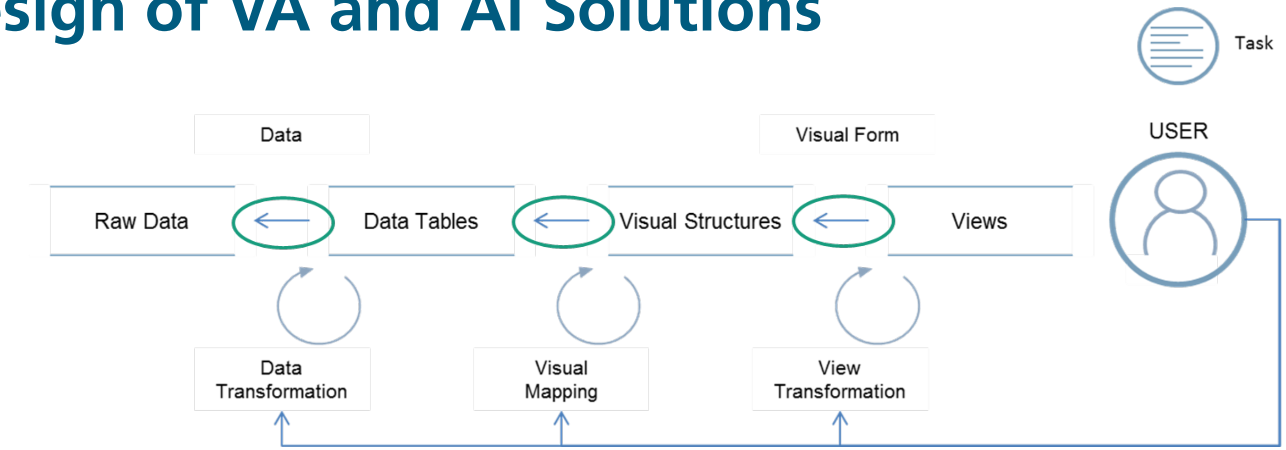
Monitor and interrupt

Human approval of actions

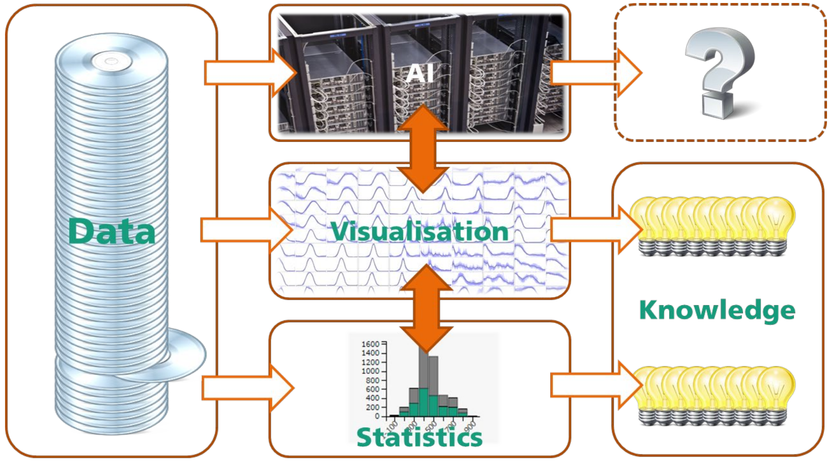
Enhancing CKD models in nephrology

User-Centered Design of VA and AI Solutions

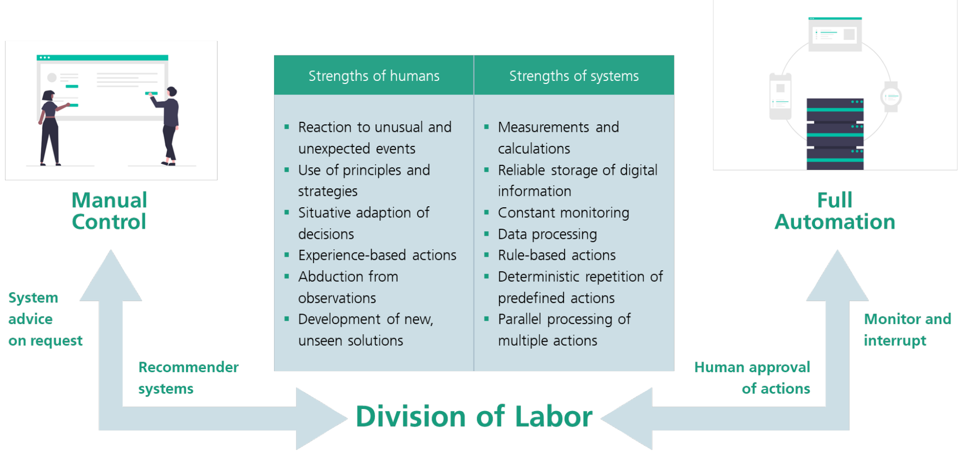
Start with your users and their tasks to…



… design the combination of visualization, statistical methods, and AI/ML



… choose the right level of automation



Strengths of humans	Strengths of systems
▪ Reaction to unusual and unexpected events ▪ Use of principles and strategies ▪ Situative adaption of decisions ▪ Experience-based actions ▪ Abduction from observations ▪ Development of new, unseen solutions	▪ Measurements and calculations ▪ Reliable storage of digital information ▪ Constant monitoring ▪ Data processing ▪ Rule-based actions ▪ Deterministic repetition of predefined actions ▪ Parallel processing of multiple actions

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