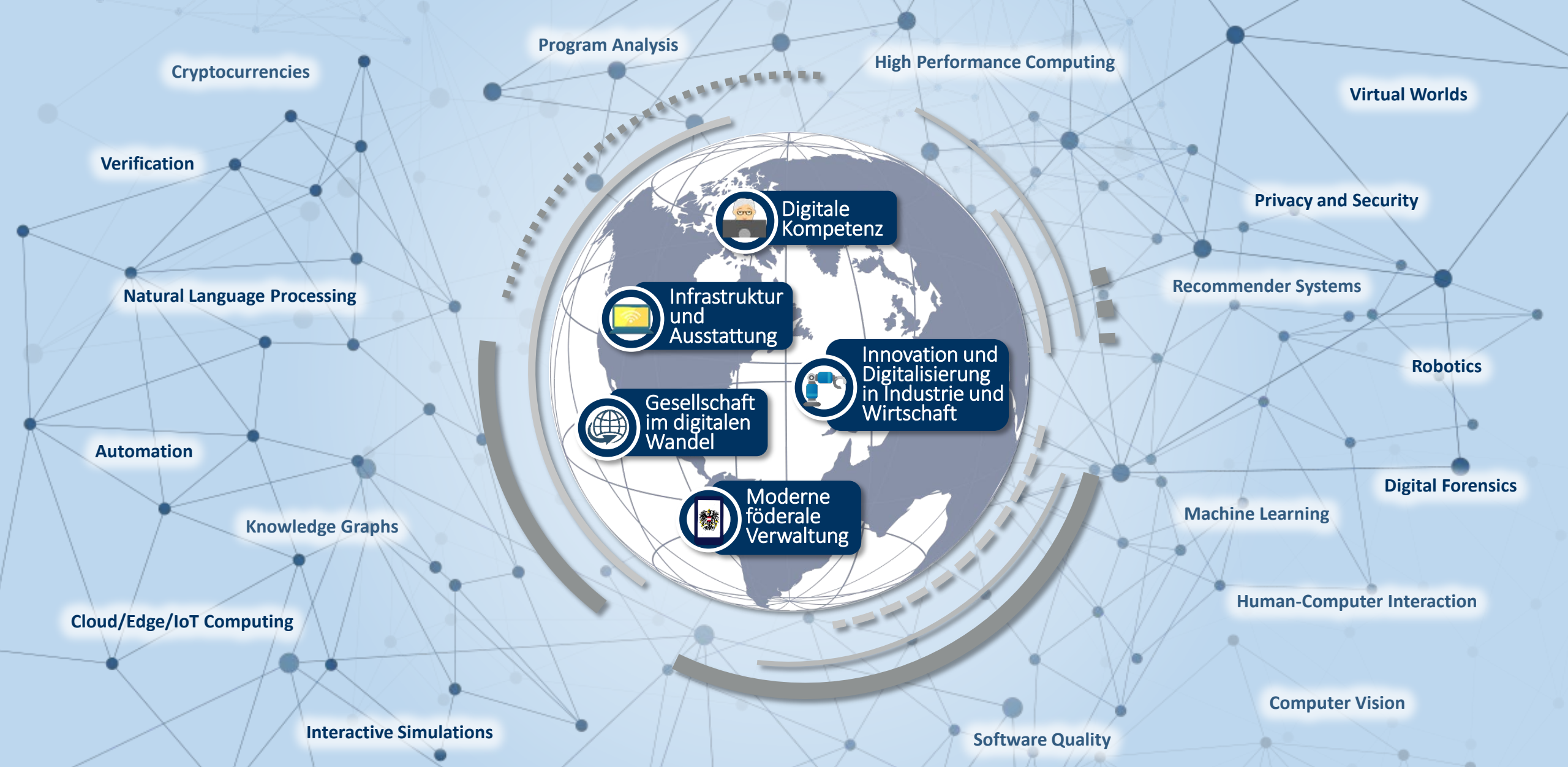


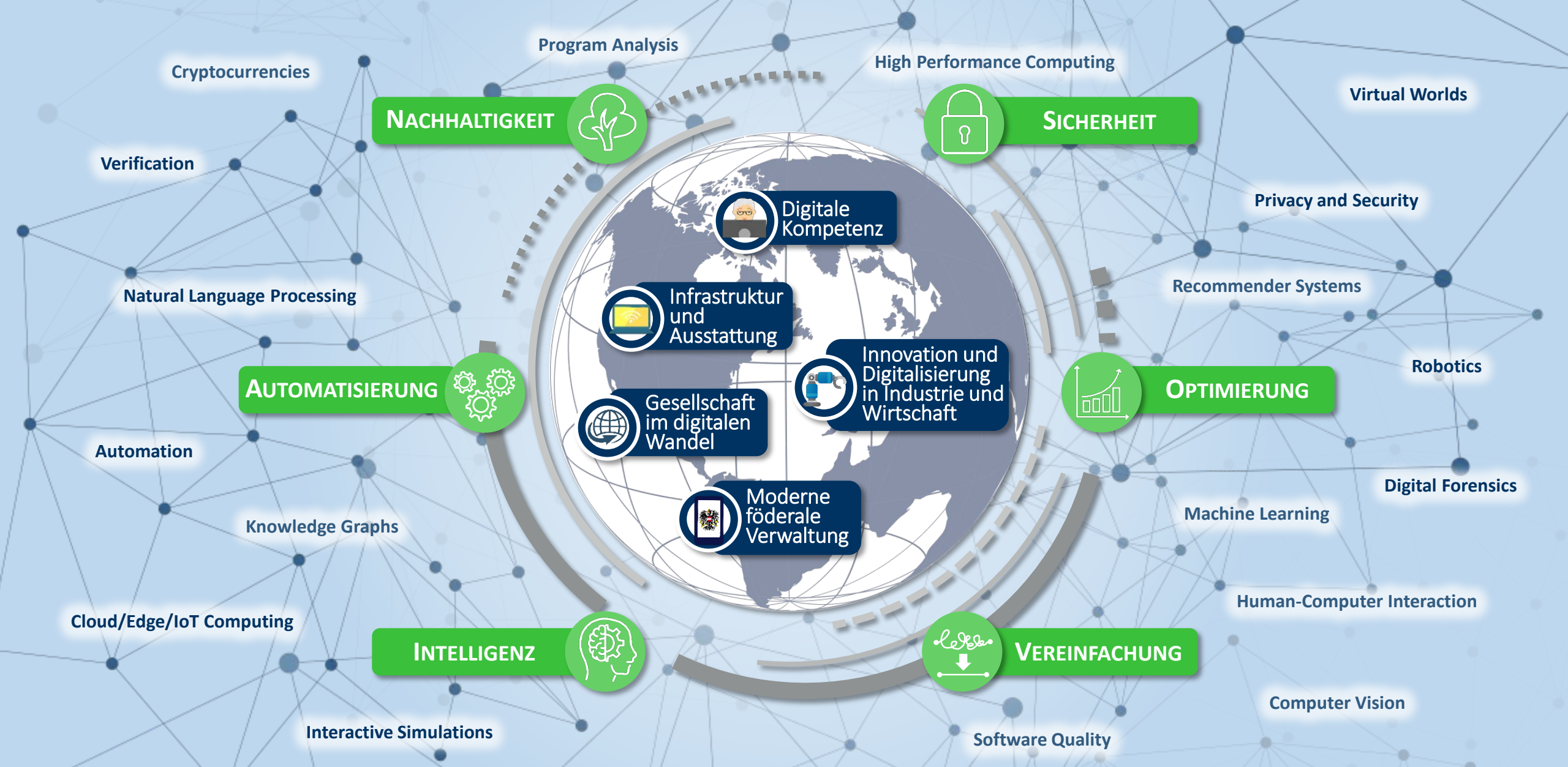
# Digitalisation.

Powered by Computer Science









# Institut für Informatik



# Institut für Informatik



# DPS – Distributed and Parallel Systems

Simplifying and optimizing for the IoT-Edge-Cloud continuum



Prof. Dr. Thomas Fahringer



Ass. Prof. Peter Thoman



Sen. Scientist Philipp Gschwandtner

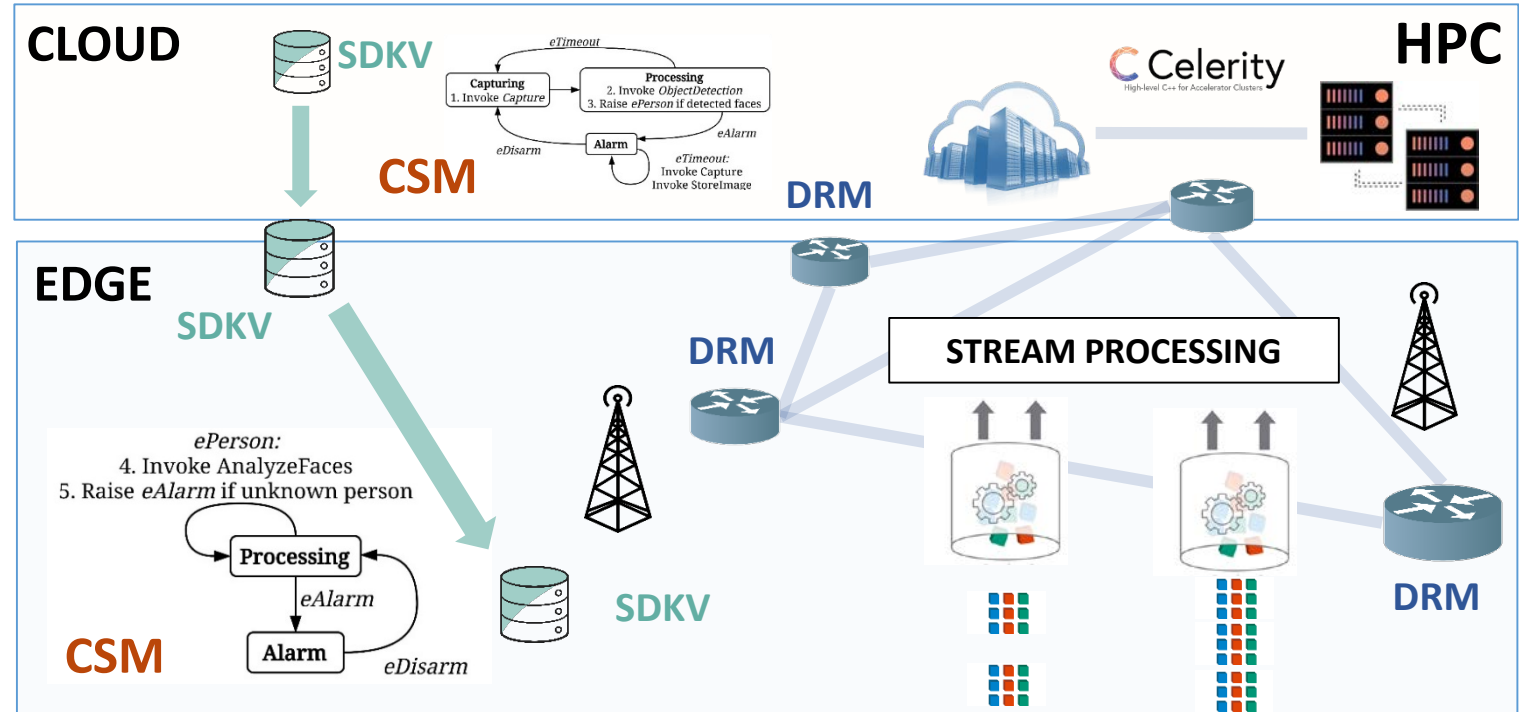


Univ. Ass. Juan Aznar



Univ. Ass. Zahra Najafabadi

- DRM: Distributed Resource Manager:
  - Automatic deployment based on SLOs
  - AI-based autoscaling techniques
- SDKV: Geo-distributed KV store:
  - Automatic Data placement and forwarding
  - Optimization for cost, latency, and energy
- Distributed Stream Processing:
  - Auto-tuning of data pipelines
  - Bio-inspired optimization of throughput and latency
- CSM: Collaborative State Machines
  - Reactive, event-driven, stateful applications
  - Disruptive programming model and runtime system
- Celerity:
  - High-productivity HPC for accelerator clusters
  - Automatic Work/Data Distribution



IOT



# SEC – Security and Privacy

## Technology that supports the rule of law

- Technological advances pose new threats to individual freedom and autonomy.
- Amplified by economic forces, they can undermine the rule of law.
- We develop technology that for principled reasons resolves or avoids conflicts.

## Law enforcement in the digital age

Forensics  
Lawfulness  
Accountability  
Chain of custody  
Technology policy



## Empower individuals

Avoid trust in third parties  
Usability and explainability  
Privacy by design

**Selected examples** **Digital money** (in collaboration with the Austrian National Bank and the MIT Media Lab)  
Detecting **hidden communication** channels of **organized crime** (EU Horizon 2020)  
Efficient cryptography for **privacy-preserving** protocols (POSEIDON secures \$500 M in Zcash)



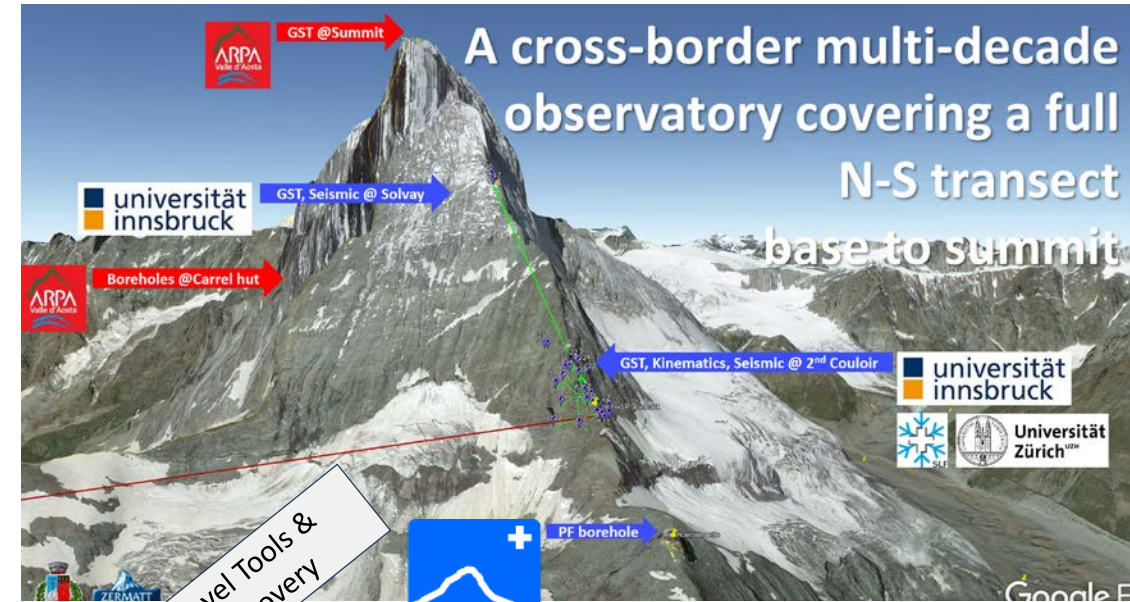
# NES – Networked Embedded Sensing Center @ Fürstenweg 176

## In-situ sensing of the mountain cryosphere

- Interdisciplinary basic research, process studies
  - Root causes of catastrophes, natural hazards
  - Climate impacts → policy making
- State-of-the-art outdoor laboratories
  - Focus on steep topography, high altitude
  - Pioneers in low-power wireless connectivity & sensing
- Our data center @ UIBK
  - Serving real-time data products to research partners
  - Publishing of open-data, curated data sets
  - Open-source tool development
- Expert services, field work safety, outreach, media



Univ.-Prof. Jan Beutel  
[jan.beutel@uibk.ac.at](mailto:jan.beutel@uibk.ac.at)



**Novel Tools & Discovery**

**PERMOS Swiss Permafrost Monitoring Network**

**Data & Methods**

**GCOS** WORLD METEOROLOGICAL ORGANIZATION

**ipcc** INTERGOVERNMENTAL PANEL ON climate change

**Guardaval**

[Weber et al: *A decade of detailed observations (2008-2018) in steep bedrock permafrost at the Matterhorn Hörnli-grat (Zermatt, CH)*. Earth Syst. Sci. Data, 11, 1203–1237, 2019. IF 10.951

A. Cicoira, J. Beutel, J. Faillietaz, A. Vieli: *Water controls the seasonal rhythm of rock glacier flow*. Earth and Planetary Science Letters, 528, 2019.

S. Weber, J. Beutel, M. Häusler, P.R. Geimer, D. Fäh, and J.R. Moore: *Spectral amplification of ground motion linked to resonance of large-scale mountain landforms*. Earth and Planetary Science Letters, Volume 578, 2022.

Leinauer, J., Weber, S., Cicoira, A. et al. *An approach for prospective forecasting of rock slope failure time*. Commun Earth Environ 4, 253 (2023). IF 7.9]

# DBIS – Databases and Information Systems

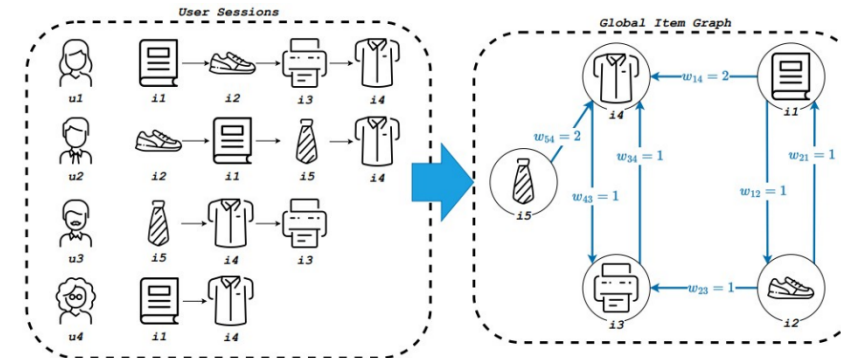


Prof. Dr.  
Günther Specht

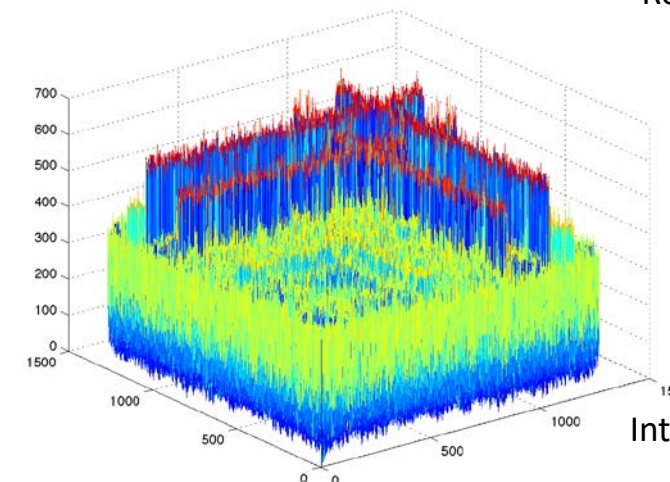


Ass.-Prof. Dr.  
Eva Zangerle

- **Core Database Development**
  - Index structures for in-memory databases
  - Graph databases
- **Recommender Systems**
  - Context-aware recommender systems
  - Psychology-driven recommender systems
  - Sequential recommender systems
  - Explanations for recommendations
  - Evaluation methods
- **Writing Style Analysis**
  - Intrinsic plagiarism detection
  - Authorship classification
  - Multi-author writing style analysis
  - Cross-language grammar features
  - Detection of generated texts



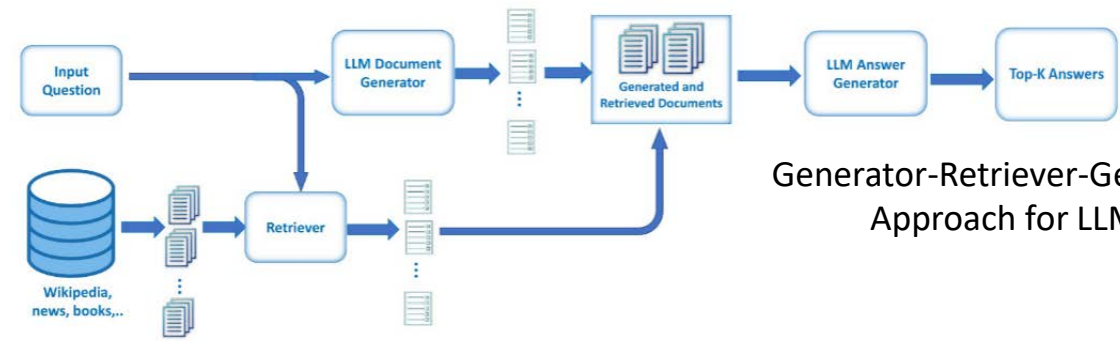
Recommender Systems



Intrinsic Plagiarism Detection

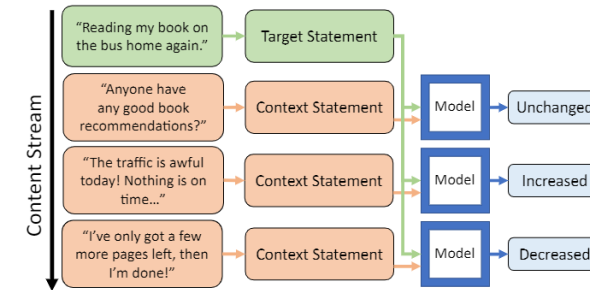
# DS – Data Science

## Research topics (NLP, IR)



Generator-Retriever-Generator Approach for LLMs

- Retrieval-Augmented Generation in LLMs
  - Improving re-ranking techniques by:
    - Using hints as parts of prompts
    - Teacher-student model for re-ranking
  - Temporal adjustments to RAG: TemporalDPR
- Temporal commonsense reasoning of LLMs
  - Assessing time reasoning capabilities
  - Methods for estimating content's temporal validity
  - Context-based temporal validity assessment
- Automatic Hint Generation
  - Hinting as an alternative to direct question answering
  - Exploring different types of hints
  - Proposing evaluation measures for generated hints
- Temporal Question Answering
  - Retrieving temporal knowledge from document archives
  - QA from OCR'd content
  - Mitigating temporal ambiguity in question answering



Context-based estimation of changes in action duration (content temporal validity)

Question: In which city are the headquarters of the International Monetary Fund?

Hint	HICOS	HIFAS
The city is known for its neoclassical architecture.	2	5
The city is located on the Potomac River.	4	3
The city is the capital of the USA located on the east coast.	5	5

Question: Which actor did Jennifer Anniston marry in July 2000?

Hint	HICOS	HIFAS
He is known for his good looks and often listed as a Hollywood heartthrob.	4	5
This actor starred in 'Fight Club' alongside Edward Norton.	5	5
He received an Oscar for his performance in 'Once Upon a Time in Hollywood'.	5	2

Examples of generated hints (our TriviaHG dataset)

No.	Question	Answer	Newspaper Title	Publication Date	State
1.	Which army was marching slowly towards Madrid?	French	The Portland Gazette	1823-03-17	Maine
2.	Who was sheriff of the county of Hanover?	Jesse Winn	Daily Richmond Whig	1830-08-12	Virginia
3.	On what day will the Anti Slavery Society of Newport hold their quarterly meeting?	November 19, 1840	Herald of the Times	1840-11-19	Rhode Island
4.	Along with Texas, in what state is the rush of immigrants prodigious?	California	The Texas Republican	1850-02-21	Texas
5.	How much is the interest rate in Seattle property loans?	10 percent	The Seattle Post-intelligencer	1892-09-02	Washington
6.	Who was the agency that ran the horses for the Sioux Indians?	Red Cloud Indian	Sierra County Advocate	1902-06-27	New Mexico
7.	Who was fined \$1 by the mayor?	Parker	The Marion Daily Mirror	1907-07-30	Ohio
8.	What club did Frank Bishop belong to?	the National Athletic Club	Sierra County advocate	1914-04-01	Montana

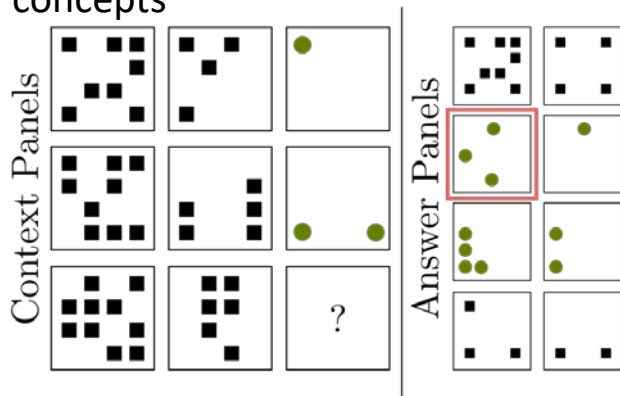
Example questions from news archive (our ChroniclingAmericaQA dataset)

# IIS – Intelligent and Interactive Systems

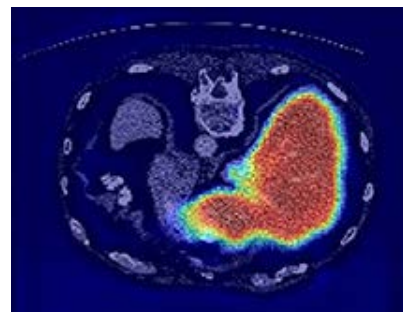
Beyond data-driven learning – towards understanding in artificial sensorimotor systems

## Computer Vision

Learning of abstract visual concepts



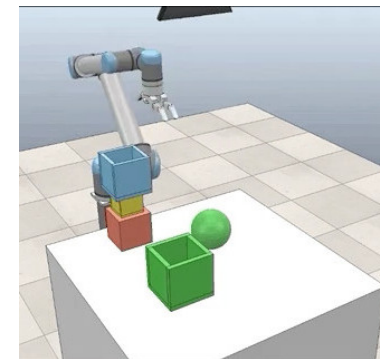
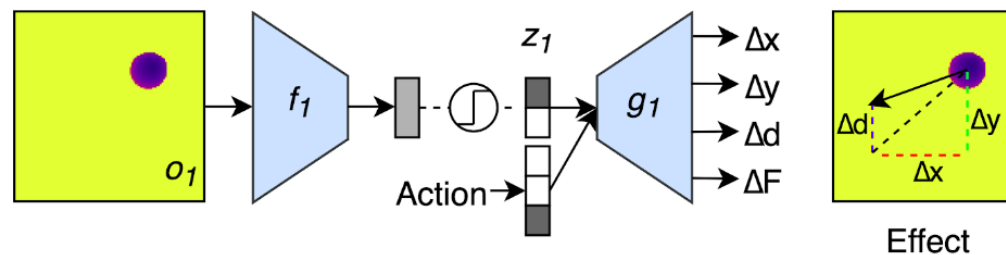
Detection and classification of avalanches



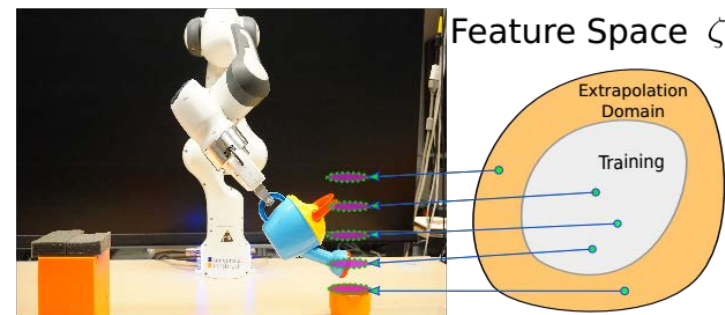
Medical image segmentation

## Robotics

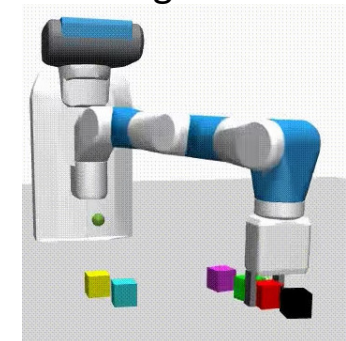
Learning planning operators



Learning generalizing motion representations



Skill learning by creating structure



# IGS – Interactive Graphics and Simulation

## Interactive Simulations, Virtual Worlds, HCI

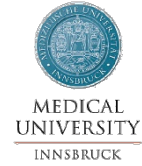
(Key applications in medical domain)



Prof. Dr. Matthias Harders

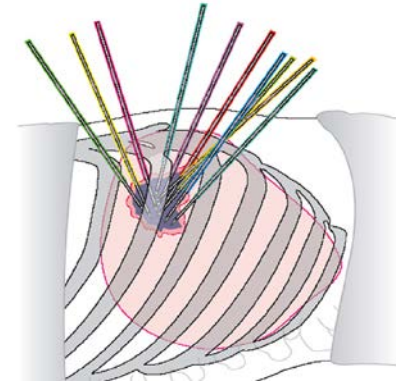
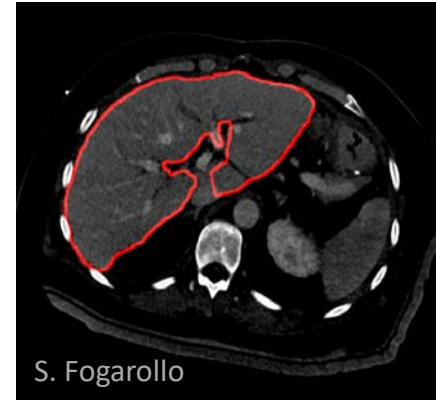
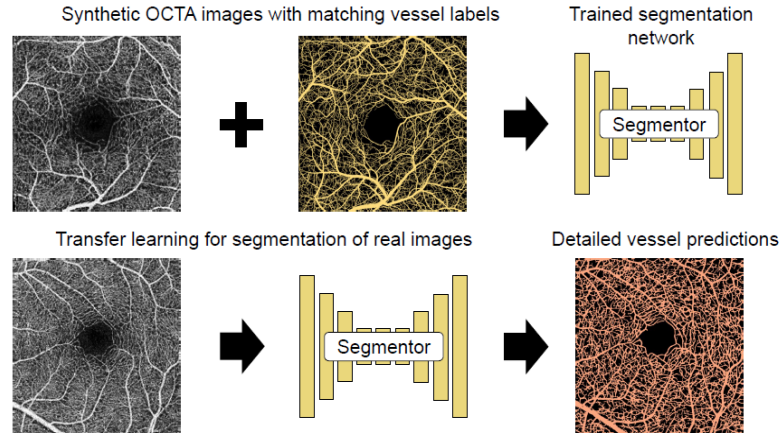
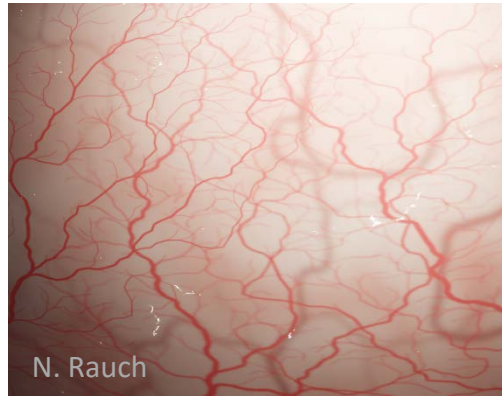


Ass. Prof. Pascal Knierim

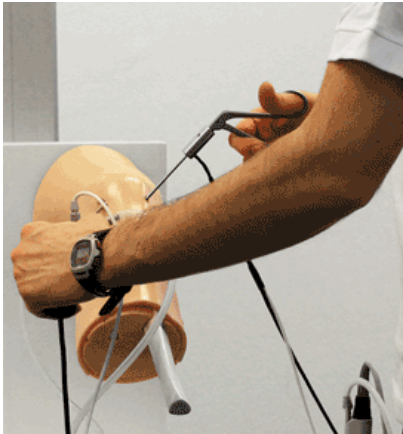


Deep learning for surgical planning

Anatomical growth models



Surgical training systems



VIRTAMED



(Patent EP3895679)

VR-based stroke rehab

# QE – Quality Engineering

## Software Engineering

- Software Quality
- Safety Assurance
- Software Traceability
- Model & Language Engineering

## Security Engineering

- Cyber Threat Intelligence Sharing
- Information Security Risk Management & Compliance
- Cyber Resilience

## Digital Twins

- Digital Twin Engineering
- Digital Twin Repositories
- Runtime Monitoring
- Cyber-Physical Systems Engineering

## Cloud Engineering

- Interoperability & Portability
- Performance Engineering
- Runtime Optimization

## Programming Education

- Programming Learning Analytics
- Automated Programming Assessment Systems

## Business-IT Ecosystems

- Enterprise Architecture Management
- Digital Transformation Processes
- Data Analytics for SDGs



Prof. Dr.  
Ruth **Breu**



Ass. Prof.  
Sashko **Ristov**



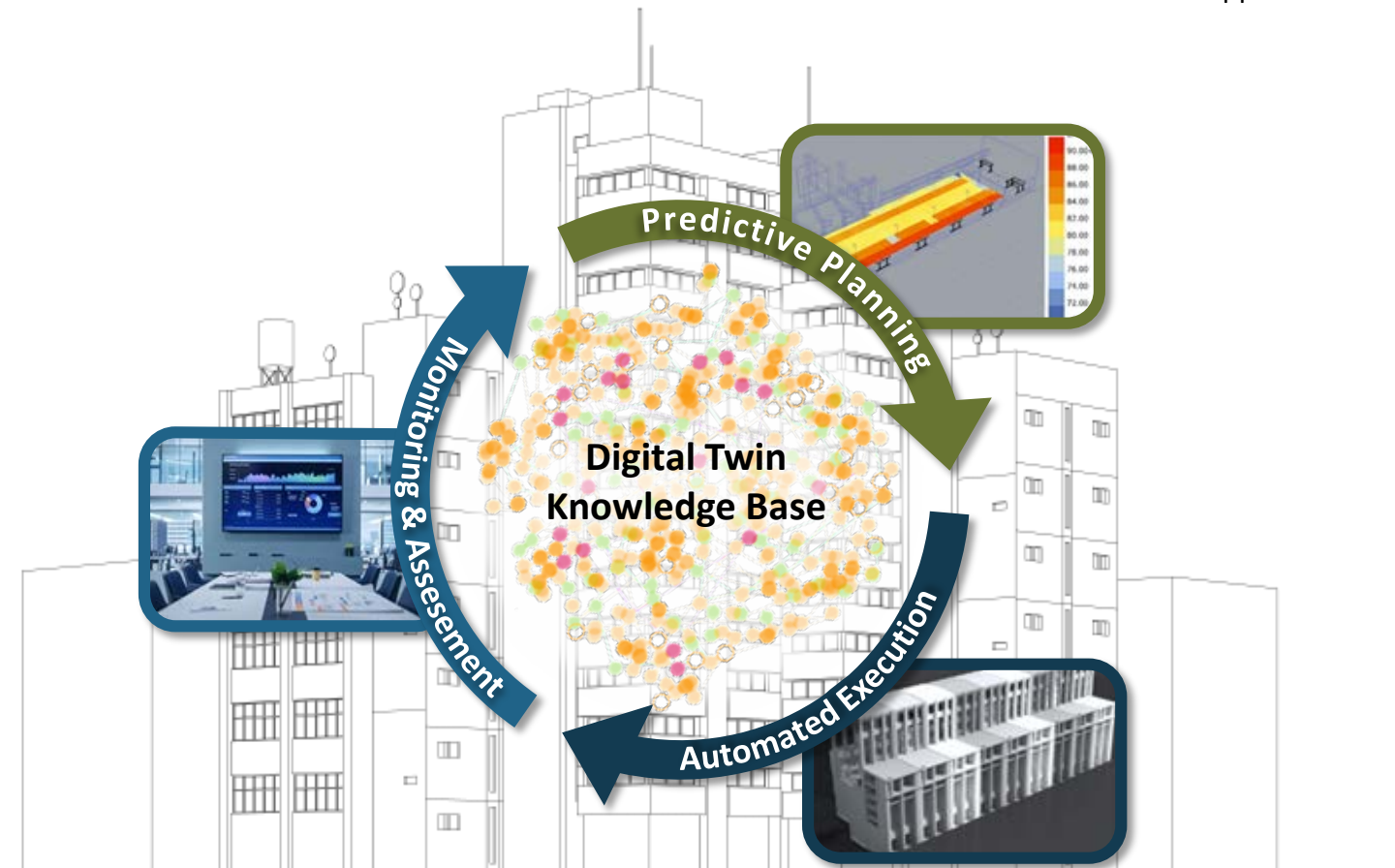
Ass. Prof.  
Clemens **Sauerwein**



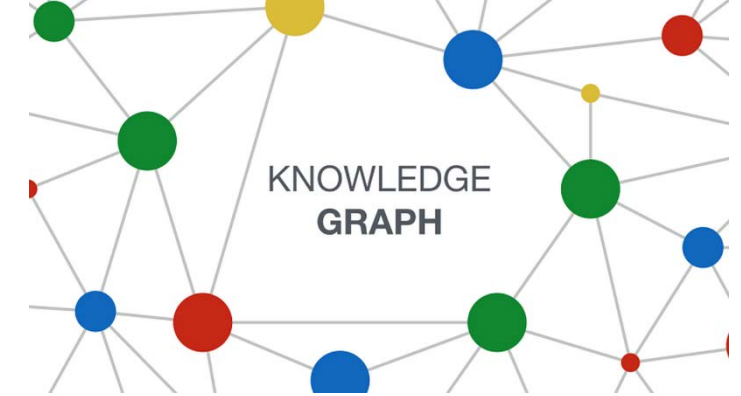
Ass. Prof.  
Michael **Vierhauser**



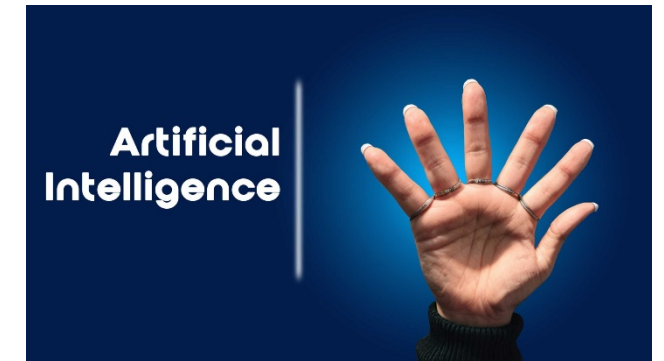
Ass. Prof.  
Philipp **Zech**



# STI – Semantic Technology Innsbruck



- The **Semantic Web** started to make information on the web machine understandable including content, data, and services.
- These large semantic data set from the web (and meanwhile from many other sources) form large (billions/trillions of facts) **knowledge graphs** that provide explicit knowledge on various domains.
- The explicit representations of facts, rules, and provenance provide explainable results available for explicit updates.
- **LLMs** work more with content only and derive (implicit) correlations of words to generate new statements.
- Much research in academia and industry is now about to combine both approaches to handle bias, explainability, integration of data and services, explicit provenance, and to prevent **hallucination**.

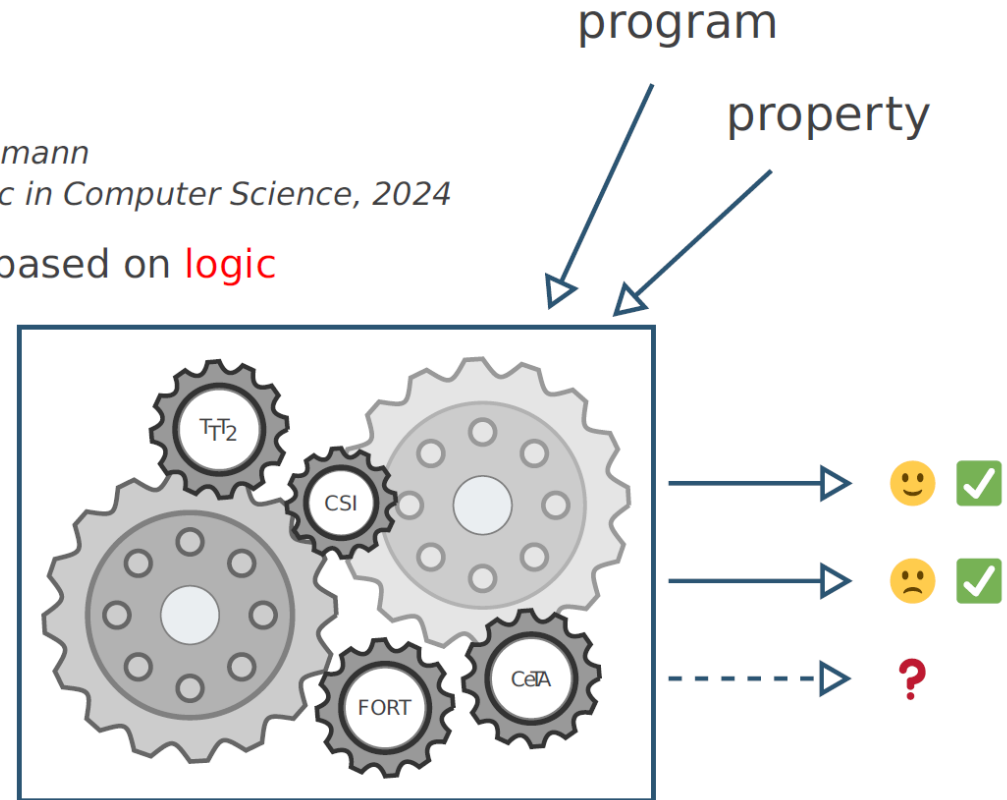
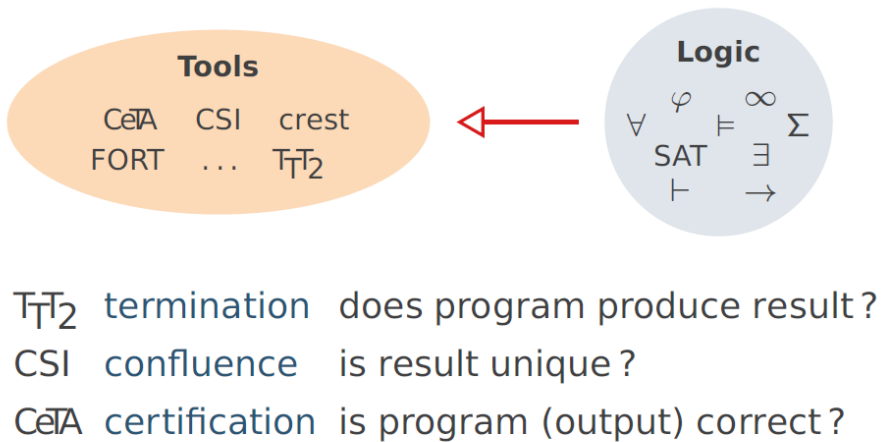


# CL – Computational Logic

... studies the limitations of **computation**

*Linear Termination is Undecidable*  
 Fabian Mitterwallner, Aart Middeldorp, René Thiemann  
 Proc. 39th Annual ACM/IEEE Symposium on Logic in Computer Science, 2024

... develops state-of-the-art verification tools based on **logic**

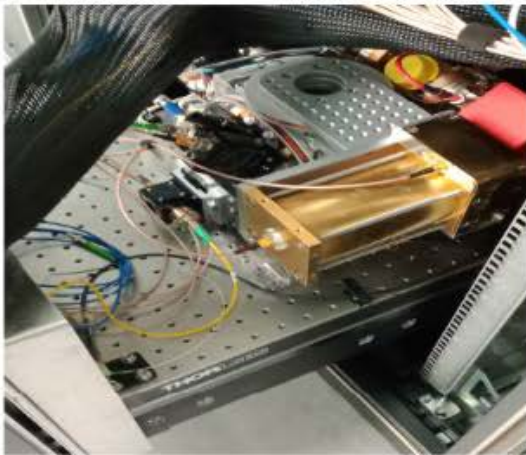




# TCS - Theoretical Computer Science

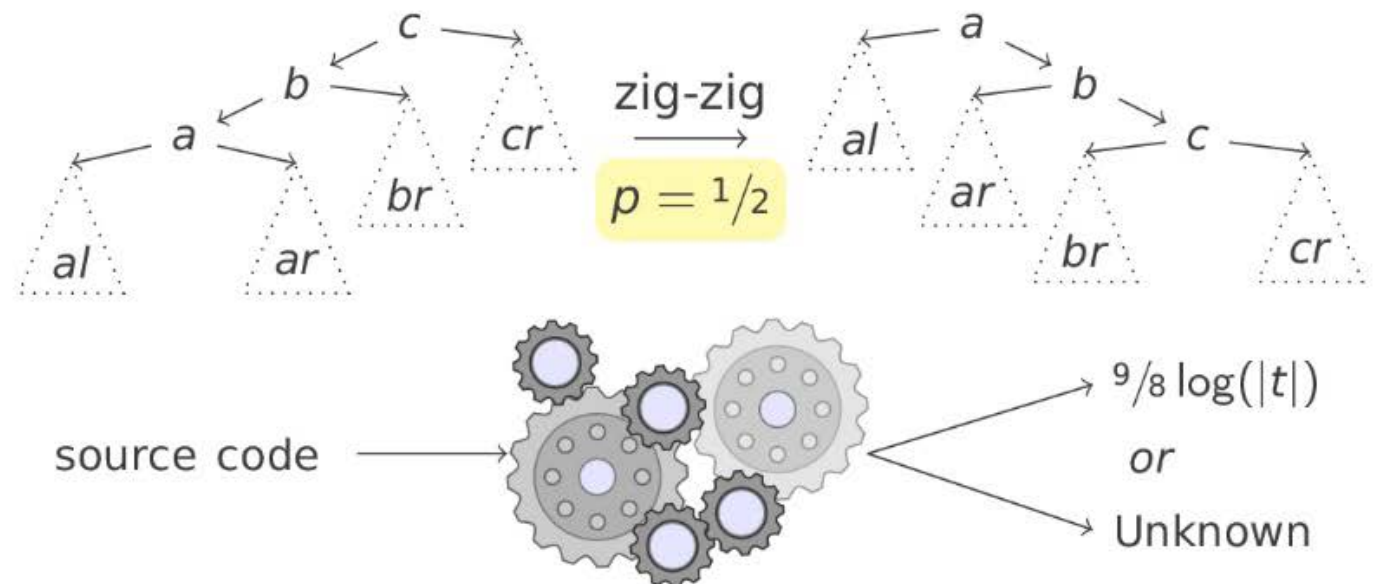
## Automated Verification

```
year = ORIGINYEAR; /* = 1980 */  
while (days > 365) {  
  if (IsLeapYear(year))  
    if (days > 366) {  
      days -= 366; year += 1; }  
  else {  
    days -= 365; year += 1; }  
}
```



## of Non-Functional Properties

```
splay x t = match t with  
| node cl c cr -> match cl with  
| node bl b br -> match tick 1 2 splay x bl with  
| node al a ar -> if coin  
  then tick 1 2 node al a (node ar b (node br c cr))  
  else node (node (node al a ar) b br) c cr
```



# Current Developments & Outlook

## IFI is at the Core of AI

### §98 Professorships on the Foundations of AI

- Artificial Intelligence
- Edge-AI Endowed Professorship

### Research Centre "Artificial Intelligence"

- connect individual AI activities and stakeholders at UIBK
- create a broader AI profile/vision for UIBK
- strengthen AI research through new initiatives
- increase visibility, exposure of competence portfolio

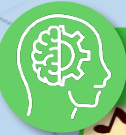
## §98 Professorships

- four professorships will be reappointed by 2030
- new professorship on "Quantum Computer Science"



### 11 Research Groups

from "automation" to "virtual worlds"



### Innovation in digital media and entertainment



### universität innsbruck




- Research Areas (DiSC, Scientific Computing, Mountain Regions)
- Research Centers (Digital Humanities, HPC)



### Green IT

- optimisation for energy and CO<sub>2</sub> consumption




### Digitale Kompetenz



### Infrastruktur und Ausstattung



### Gesellschaft im digitalen Wandel



### Innovation und Digitalisierung in Industrie und Wirtschaft



### Moderne föderale Verwaltung



### SMEs



### POLIZEI

- forensics
- lawfulness
- ...