Seminars @ Knowledge-based Systems Group 192-03

WS 2023/24

Seminar Topic Presentation

Institute of Logic and Computation
Knowledge-Based Systems Group

www.kr.tuwien.ac.at

Overview

Offered Seminars:

➤ Seminar in Theoretical Computer Science

➤ Seminar in Artificial Intelligence

➤ Seminar in Logic

➤ Seminar in Knowledge Representation and Reasoning

Organisation:

➤ Any of the topics listed in the following can be chosen for any of our offered seminars.

➤ A 40min presentation has to be prepared.

➤ The talks will be given at the end of the semester.

Topics

Topics Group Tompits

➤ Nonstandard Proof Systems

➤ Metalogic: Theory of Signs

➤ Cognitive Psychology and its Implications

➤ AI and Music

➤ History of Logic I

Topics Group Eiter

➤ History of Logic II

➤ Theory and Logic

➤ Knowledge Representation and Reasoning

➤ Artificial Intelligence

Topics (ctd.)

Topics Group Ortiz
➤ Fairness in AI
➤ Planning and Reasoning in LLMs
➤ Formal XAI: Verification of (Deep) Neural Networks
➤ Learning Ontologies
➤ Formalisms for Graph Data: GQL, SHACL, PG schema. . . .

Topics Group Egly
➤ Problem Solving on a Quantum Computer

Assignment
☞ If you are interested in a topic of group X, then please write an email with subject "[KBS SE]" to person X.
☞ Additionally, please register to the group X of the seminar(s) for which you want to receive your certificate(s).

Nonstandard Proof Systems

➤ Traditionally, proof calculi axiomatise the valid formulas of a logic.

➤ But we can also have calculi which axiomatise different classes of formulas of a logic:

- the *non-valid formulas* ("rejection calculi", often also called "refutation systems");

- the *unsatisfiable formulas* ("refutation systems", "opposite systems");

- the *contingent formulas* (those which are neither valid nor unsatisfiable).

➡ We discuss some calculi proposed in the literature along these lines.

- Examples of Hilbert-type calculi for unsatisfiable formulas:

  - G. Stahl. *An Opposite and an Expanded System*, 1958.

  - C.G. Morgan. *Sentential Calculus for Logical Falsehoods*, 1973.

  - J.H. Sobel. *Nether Logic*, 1994.

Metalogic: Theory of Signs

Metalogic deals with the the metatheory of logic and was famously championed, among others, by C.S. Peirce (1839-1914).

An important part of metalogic is *semiotics*, the theory of signs.

➤ Umberto Eco: *A Theory of Semiotics*, Indiana University Press, 1976
  - From the contents:
    1. Introduction & Signification and Communication
       [1 presentation]
    2. Theory of Codes [2 presentations]
    3. Theory of Sign Production & The Subject of Semiotics
       [3 presentations]
  ☞ Umberto Eco (1932-2016), widely known as a novelist, like his 1980 novel The Name of the Rose.

➤ Alonzo Church: *Introduction to Mathematical Logic*, Volume I, 1956, §0 Introduction

Cognitive Psychology and its Implications

➤ John R. Anderson: *Cognitive Psychology and its Implications*, Eighth Edition, 2014

➤ From the Contents:

1. Perception
2. Attention and Performance
3. Mental Imagery
4. Representation of Knowledge
5. Human Memory
6. Problem Solving
7. Expertise
8. Reasoning
9. Judgement and Decision Making
10. Language Structure
11. Language Comprehension
12. Individual Differences in Cognition

AI and Music

➤ Methods for automated composition
   - machine learning methods
   - knowledge-based methods (using, e.g., answer-set programming, constraint-satisfaction methods, machine learning)
   - genetic algorithms
   - stochastic algorithms

➤ Music recommender systems (e.g., automated playlist generation for music streaming)

➤ Music recognition and classification algorithms

➤ Technical aspects of computer music
   - Shannon's sampling theorem
   - AD/DA conversion techniques (PCM, DSD, oversampling, anti-aliasing, lossy and lossless data reduction)
   - DSP methods

History of Logic I

Milestones of Logic:

➤ David Hilbert und Wilhelm Ackermann: Grundzüge der theoretischen Logik, 1928

- From the contents:
  - Consistency and independence of the axiom systems
  - The decision procedure
  - The class calculus (monadic predicate logic)
  - Second-order predicate logic

➤ Rudolf Carnap:
- Abriss der Logistik, 1929.
- Meaning and Necessity: A Study in Semantics and Modal Logic, 1947

History of Logic I (ctd.)

➤ Gabbay & Woods: *Handbook of the History of Logic, Volume 11: A History of its Central Concepts*, 2012

➤ From the contents:

1. History of the Consequence Relation
2. A History of Quantification
3. A Brief History of Negation
4. A History of the Connectives
5. A History of Truth-Values
6. A History of Modal Traditions
7. A History of Natural Deduction
8. A History of Connexivity
9. A History of Types
10. A History of the Fallacies in Western Logic
11. A History of Logic Diagrams

History of Logic (II)

➤ **Logicomix**
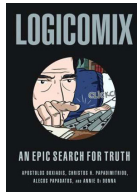
- An entertaining journey through the beginnings of modern formal logic
- Tell the story and zoom into some technical aspect

History of Logic (II)

Charles Sanders Peirce (1839–1914)

➤

- Philosopher, mathematician, logician, and many more
- Studied abductive reasoning, inductive reasoning, deductive reasoning and their interrelationship
- Developed *existential graphs*, ako diagrammatic version of predicate calculus

➤ Report on life & some technico-philosophical achievement(s)

Theory and Logic

➤ *Algebraic Model Counting* (JAL, 2017)

➤ *On Quantifying Literals in Boolean Logic and its Applications to Explainable AI* (IJCAI 2022, JAIR)

➤ *Signal Temporal Logic: Monitoring Temporal Properties of Continuous Signals* (FORMATS/FTRTFT'04)

➤ *LTL on Weighted Finite Traces: Formal Foundations and Algorithms* (IJCAI 2022)

➤ *Verification and Realizability in Finite-Horizon Multiagent Systems* (KR 2022)

➤ *The Logical Expressiveness of Graph Neural Networks* (ICLR 2020)

Knowledge Representation and Reasoning

➤ **Temporal and Stream Reasoning**

- *MeTeoR: Practical Reasoning in Datalog with Metric Temporal Operators* (AAAI 2022)

- *I-DLV-sr: A Stream Reasoning System based on I-DLV* (TPLP 2021, RR+RW 2022)

- *RDF Stream Reasoning via Answer Set Programming* (ISWC'18)

- *Stream Reasoning in Temporal Datalog* (AAAI 18)

- *Handling Impossible Derivations During Stream Reasoning* (ESWC 2020)

- *Abnormal Situations Interpretation in Industry 4.0 using Stream Reasoning* (KES 2019)

- *Out of Sight But Not Out of Mind: Traffic Analysis in ASP* (IJCAI 2019)
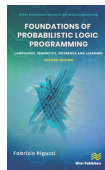
Knowledge Representation and Reasoning, cont'd

➤ **Logic Programming with Uncertainty**

- *Book: Foundations of Probabilistic Logic Programming*

2018

2023

1. Preliminaries
2. Probabilistic Logic Programming Languages
3. Semantics with Function Symbols
4. Hybrid Programs
5. Semantics for Hybrid Programs with Function Symbols
6. Probabilistic Answer Set Programming
7. Complexity of Inference
8. Exact Inference

9. Lifted Inference
10. Approximate Inference
11. Non-Standard Inference
12. Inference for Hybrid Programs
13. Parameter Learning
14. Structure Learning
15. cplint Examples
16. Conclusions

- *Plingo: A Probabilistic ASP Solver* (arXive 2022)

- *DeepStochLog: Neural Stochastic Logic Programming* (AAAI 2022)

Knowledge Representation and Reasoning, cont'd

➤ **Rule Learning**

- *Popper: Learning Programs By Learning From Failures* (Machine Learning, 2021)

- *Hopper: Learning Higher-Order Logic Programs from Failures* (IJCAI 2022)

- *FOLD-R++: A Scalable Toolset For Automated Inductive Learning of Default Theories From Mixed Data* (FLOPS 2022)

- *Learning First-Order Rules with Differentiable Logic Program Semantics* (IJCAI 2022)

- *Faithful Approaches to Rule Learning* (KR 2022)

Artificial Intelligence

➤ **Explainability**

- *Explanation in Artificial Intelligence: Insights From the Social Sciences* (AIJ, 2019)

- *xclingo: A System for Explainable Answer Set Programming* (ICLP 2020)

- *On Quantifying Literals in Boolean Logic and its Applications to Explainable AI* (IJCAI 2022, JAIR)

- *Tractable Explanations for d-DNNF Classifiers* (AAAI 2022)

- *On the Computation of Necessary and Sufficient Explanations* (AAAI 2022)

- *An ASP-Based Approach to Counterfactual Explanations for Classification* (RuleML+RR 2020)

Artificial Intelligence

➤ **Neuro-Symbolic AI**

- *Logic Tensor Networks* (NESY 2016, IJCAI 2017)
- *Neural-Symbolic Integration: A Compositional Perspective* (AAAI 2021)
- *Neuro-Symbolic AI for Compliance Checking of Electrical Control Panels* (ArXive 2023)
- *A Symbolic-Neural Reasoning Model for Visual Question Answering* (ICNN, 2023)
- *Knowledge-Based Counterfactual Queries for Visual Question Answering* (AAAI-MAKE 2023)
- *Reliable Natural Language Understanding with Large Language Models and Answer Set Programming* (ICLP 2023)
- *Leveraging Large Language Models to Generate Answer Set Programs* (arXive 2023)
- *Coupling Large Language Models with Logic Programming for Robust and General Reasoning from Text* (arXive 2023)

Artificial Intelligence, cont'd

➤ **Normative Reasoning**

- *Obligation as Optimal Goal Satisfaction* (J. Philosophical Logic, 2018)

- *Temporal Deontic Action Logic For the Verification of Compliance to Norms in Asp* (ICAIL 2013)

- *Norm Conflict Resolution in Stochastic Domains* (AAAI 2018)

- *A Normative Supervisor for Reinforcement Learning Agents* (CADE, 2021)

- *Multi-Objective Reinforcement Learning for Designing Ethical Environments* (IJCAI 2021)

- *Defeasible Normative Reasoning* (Synthese, 2020)

- *Practical Reasoning with Norms for Autonomous Software Agents* (EAAI, 2017)

- *Piecemeal Knowledge Acquisition for Computational Normative Reasoning* (AIES 2022)

Artificial Intelligence, cont'd

➤ **AI Classics & Highlights**

- *HAL / 2001: A Space Odyessy*
- *DeepBlue*
- *AlphaGo & Co*
- *Libratus & Pluribus*
- *Sony's Gran Turismo Sophy*$^{\text{TM}}$ (ACM SIGAI Industry Award, 2022)
- *Interpretable Machine Learning: Bringing Data Science Out of the "Dark Age"* (Squirrel Award 2022)
- *Kidney/Organ Exchange* (AAAI 2016, AAAI 2012)
  www.cs.cmu.edu/~sandholm/organExchangeTutorials/organExchangeTutorial.aaai16.html
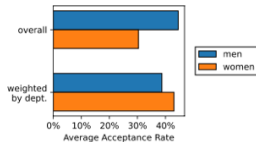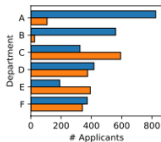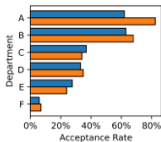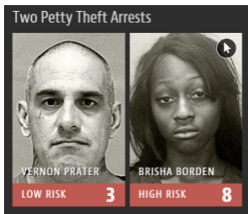- *ChatGTP & co*
- *. . .*

Access to papers:

https://owncloud.tuwien.ac.at/index.php/s/j1SE8IdAHWITEEA   password: sem1923

Also possible: similar / related topics, your proposal!

AI Fairness

➤ *Inherent Limitations of AI Fairness*, Buyl & De Bie, 2023

➤ *Maximal Fairness*, Defrance & De Bie, 2023

Planning and Reasoning in LLMs

➤ *On the Planning Abilities of Large Language Models: A Critical Investigation*, Valmeekam et al. 2023

➤ *On the Paradox of Learning to Reason from Data*, Zhang et al. IJCAI 2023

Formal XAI: verification of neural networks

➤ *Logic for Explainable AI*, Adnan Darwiche, LICS 2023

➤ *Towards Trustable Explainable AI*, Ignatiev, IJCAI 2020

➤ *On the Computation of Necessary and Sufficient Explanations*
Darwiche & Ji, AAAI 2022

➤ *Explanations for Monotonic Classifiers*, Marques-Silva et al. ICML
2021

Formalisms for graph data: GQL, SHACL, PG schema

➤ *PG-Schema: Schemas for Property Graphs*, 2023
➤ *A Researcher's Digest of GQL*, 2023
   `https://www.gqlstandards.org/`

Shapes Constraint Language (SHACL)
W3C Recommendation 20 July 2017

W3C

Learning ontologies

➤ *Learning Description Logic Ontologies: Five Approaches. Where Do They Stand?* Ana Ozaki 2020

➤ *SAT-Based PAC Learning of Description Logic Concepts* ten Cate et al. IJCAI 2023: 3347-3355

➤ *Learning Description Logic Concepts: When can Positive and Negative Examples be Separated?* Funk et al., IJCAI 2019

Problem Solving on a Quantum Computer (1)

▶ Barenco et al. *Approximate Quantum Fourier Transform and Decoherence*. https://arxiv.org/abs/quant-ph/9601018

▶ Mosca/Ekert: *The Hidden Subgroup Problem and Eigenvalue Estimation on a Quantum Computer*. https://arxiv.org/abs/quant-ph/9903071

▶ J. Proos, C. Zalka: *Shor's Discrete Logarithm Quantum Algorithm for Elliptic Curves*. https://arxiv.org/abs/quant-ph/0301141

▶ B. Duan et al.: *A survey on HHL algorithm: From theory to application in quantum machine learning*. Physics Letters A, Volume 384, Issue 24, 2020.

▶ SAT problems on a quantum computer
Starting point: Grover: *A fast quantum mechanical algorithm for database search*. STOC, 1996. https://arxiv.org/abs/quant-ph/9605043

▶ The Munich Quantum Toolkit: Theory and Practice
Starting point: https://pypi.org/project/mqt.ddsim/

Problem Solving on a Quantum Computer (2)

▶ Bernstein/Vazirani: *The recursive Bernstein-Vazirani Problem*
Starting point: Quantum complexity theory
https://people.eecs.berkeley.edu/~vazirani/pubs/bv.pdf

▶ Raz/Tal: *Oracle Separation of BQP and PH.* JACM 69(4), 2022
https://dl.acm.org/doi/pdf/10.1145/3313276.3316315

▶ Farhi/Goldstone: *A Quantum Approximate Optimization Algorithm.*
https://arxiv.org/abs/1411.4028