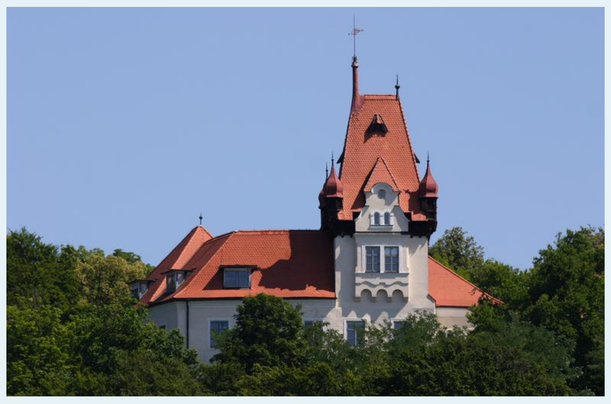
RISC
Research Institute for Symbolic Computation
https://www.risc.jku.at

JOHANNES KEPLER UNIVERSITY LINZ

"I see two main approaches. . . symbolic computation and machine learning. . .
Together, the two approaches constitute (part of) what some people like to call 'artificial intelligence'."
Bruno Buchberger: *Automated programming, symbolic computation, machine learning: my personal view*. Annals of Mathematics and Artificial Intelligence, Volume 91, pages 569–589, 2023.

The RISC Institute



- An institute of the JKU Linz founded in 1987 by Bruno Buchberger.
- Located in the Castle of Hagenberg.
- Part of the Softwarepark Hagenberg (also founded by BB).
- 1992 Spinoff: RISC Software GmbH (≈80 employees).
- ≈25 members (2 full professors, faculty of ≈10 members with PhD).
- Current director: Carsten Schneider.

Research, education, and applications of symbolic computation.

Testimonials

- *"There is no institute comparable to RISC in the US."* (US National Science Foundation Report, 1992)
- *"Die Mathematiker in Hagenberg machen phantastische Arbeit."* (Prof. Penninger, Director of the Institute of Molecular Biotechnology, Vienna, ORF Interview "Im Journal zu Gast", 2010)
- *"RISC is a high-level scientific institution, perhaps the best one on a world scale in the symbolic computation field."* (Evaluation report for the EU project SCIEnce, 2005)

International recognition of the institute.

Symbolic Computation

- Solving problems on symbolic objects (finitary representations of mathematical entities with "infinite semantics"):
  - algebraic expressions ⇝ computer algebra,
  - logical propositions ⇝ automated reasoning,
  - computer programs ⇝ "automatic programming".
- Algorithmic derivation of exact solutions to many problems that were once thought to be completely out of reach or only amenable to human intelligence.
- Software systems for computer mathematics, computer aided design and manufacturing, computer supported reasoning, knowledge management, etc.

Numerous scientific activities, projects, cooperations.

Symbolic Computation and Machine Learning

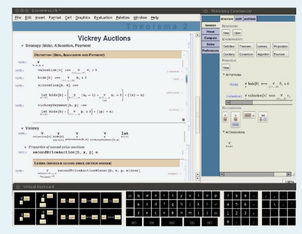
Application of ML in SC (ML→SC), application of SC in ML (SC→ML), combined approaches (ML+SC+. . .).

- Using ML methods to generate hypotheses in SC algorithms (ML→SC).
- Speeding up computer algebra methods by solving subproblems with verified output of machine learning methods (ML→SC).
- Using SC methods to analyze/verify ML algorithms (SC→ML).
- Generating algorithms from natural language specification using methods from NLP, ML, and SC (NLP+ML+SC).
- . . .

Open new ways for artificial intelligence by the interaction of symbolic computation and machine learning.

Automated Reasoning

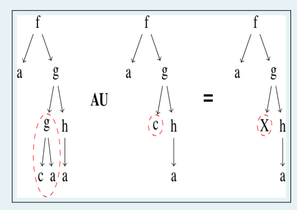
- The Theorema system for computer supported mathematical theorem proving and theory exploration in natural style on the basis of the computer algebra system Mathematica.



Bruno Buchberger, Tudor Jebelean, Temur Kutsia, Alexander Maletzky, Wolfgang Windsteiger. *Theorema 2.0: Computer-Assisted Natural-Style Mathematics*. Journal of Formalized Reasoning 9(1), pp. 149-185. 2016. doi:10.6092/issn.1972-5787/4568

Rewriting-related Techniques and Applications

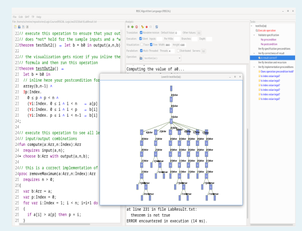
- Solving methods (both crisp and approximate/ quantitative variants) for equational constraints, generalization techniques in various theories, and calculi for rule-based transformations.



David Cerna, Temur Kutsia. *Anti-unification and Generalization: A Survey* . In: Proceedings of IJCAI 2023 — 32nd International Joint Conference on Artificial Intelligence. ijcai.org, 2023. 6563–6573. doi:10.24963/ijcai.2023/736

Formal Methods

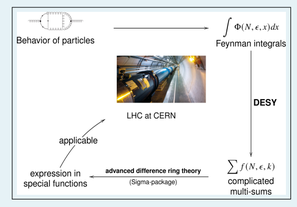
- The RISCAL software for the analysis/verification of mathematical theories and algorithms by (finite-state) model checking and (infinite-state) theorem proving.



Wolfgang Schreiner. *Concrete Abstractions — Formalizing and Analyzing Discrete Theories and Algorithms with the RISCAL Model Checker*. Texts & Monographs in Symbolic Computation, Springer International Publishing, 2023. doi:10.1007/978-3-031-24934-1

Computer Algebra and Applications

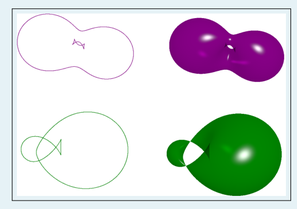
- Symbolic summation and integration, special functions, and modular forms in combinatorics, computer science, elementary particle physics, number theory, numerics.



J. Blümlein, C. Schneider, M. Saragnese. *Hypergeometric Structures in Fe ynman Integrals*. Annals of Mathematics and Artificial Intelligence 91(5), pp. 591-649 . 2023. ISSN 1573-7470. arXiv:2111.15501 [math-ph]. doi:10.1007/s10472-023-09831-8

Computer Algebra for Geometry

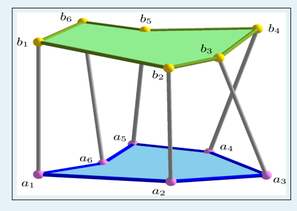
- Computer algebra methods for solving systems of polynomial equations and similar problems as the basis for a computational theory of algebraic geometry.



E. Hoxhaj, J.-M. Menjanahary, J. Schicho. *Using Algebraic Geometry to Reconstruct a Darboux Cyclide from a Calibrated Camera Picture*. Journal of Applicable Algebra in Engineering, Communication and Computing, 2023. doi:10.1007/s00200-023-00600-y

Symbolic Computation in Kinematics

- Application of algebraic geometry to the classification of closed 6R linkages, the study of pentapods and hexapods, or the construction of planar linkages.



Josef Schicho. *And Yet it Moves — Paradoxically Moving Linkages in Kinematics*. Bulletin of the American Mathematical Society, volume 59, pp. 59–95. 2022. doi:10.1090/bull/1721