THE RISC INSTITUTE

35 Years^{+} of Research in Artificial Intelligence

Research Institute for Symbolic Computation (RISC)
Johannes Kepler University Linz, Austria
https://www.risc.jku.at

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 ($\approx$80 employees).

- $\approx$25 members (2 full professors, faculty of $\approx$10 members with PhD).

- Current director: Carsten Schneider.

Research, education, and applications of symbolic computation.

Symbolic Computation

- Solving problems on symbolic objects (finitary representations of mathematical entities with "infinite semantics"):
  - algebraic expressions $\rightsquigarrow$ computer algebra,
  - logical propositions $\rightsquigarrow$ automated reasoning,
  - computer programs $\rightsquigarrow$ "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.

"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.

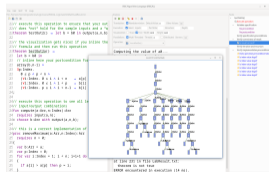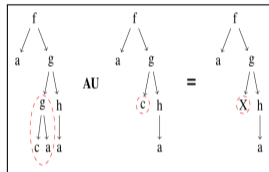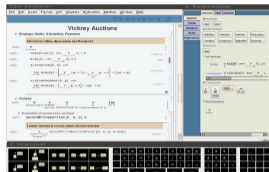# Current Research at RISC

- Automated Reasoning
  - The Theorema system for computer supported mathematical theorem proving and theory exploration in natural style.
- 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.
- Formal Methods
  - The RISCAL software for the analysis/verification of mathematical theories and algorithms by (finite-state) model checking and (infinite-state) theorem proving.

Current Research at RISC

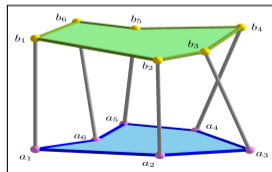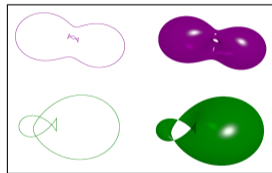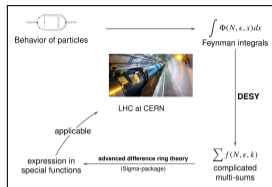- Computer Algebra and Applications
  - Symbolic summation and integration, special functions, and modular forms in combinatorics, computer science, elementary particle physics, number theory, numerics.
- Computer Algebra for Geometry
  - Computer algebra methods for solving systems of polynomial equations and similar problems as the basis for a computational theory of algebraic geometry.
- 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.

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 natural language processing, ML, and SC (NLP+ML+SC).
- ...

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