

# AI-Assisted Formal Verification of Robotic Control Systems

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## Opis teme

When a robotic arm moves near a human, "we tested it and it worked" is not enough. Formal verification produces machine-checked proofs that a system satisfies its safety guarantees for all possible states, not just the ones you happened to try.

This project asks one concrete question: can AI assistants meaningfully speed up the writing of formal proofs in control theory and robotics?

To explore it, the project develops a Lean 4 library of machine-checked theorems covering stability, controllability, manipulator kinematics, and safety invariants. Around it, focused experiments are used to test whether AI tools reduce the time from a theorem statement to a proof that Lean 4 actually accepts.

The central idea is that AI can help, but only within a tightly scoped domain and only when Lean 4 has the final word on correctness.

## Zadaci i ciljevi

The student researcher works on both aspects of the project alongside the mentor.

The first component is proving control theorems in Lean 4: selecting a small body of results from stability theory, controllability, or manipulator kinematics and beginning to formalize them. This includes translating mathematical statements into Lean 4 type-theoretic syntax, developing proof strategies, and getting the compiler to accept them.

The second component is evaluating AI assistance for those proofs: designing and running a small study of how well an existing language model can assist with writing the Lean 4 proofs. The student defines a benchmark, runs the experiments, and reports the results honestly. This is applied machine learning evaluation, not prompt engineering.

The scope is deliberately modest and suited to the PSI semester timescale with weekly check-ins. The expected outcome is a concrete artifact, a clear research question, and a measurable answer.

### **Tražene vještine od studenata**

This project is open to Bachelor and Master students with a background in mathematics, computer science, control systems, or robotics. Curiosity about formal methods or machine learning matters far more than any specific prior experience.

No prior Lean 4 experience required.

No prior ML or fine-tuning experience required.

A working knowledge of linear algebra and basic control concepts is helpful.

Required: ability to work carefully, tolerate ambiguity, and debug things that are subtly wrong.

The student should be comfortable with a version-controlled, structured workflow. Progress in this kind of work is measured in small, precise steps, not in rapid prototyping.