Some Adventures in Learning Proving, Instantiation and Synthesis

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Abstract—Human problem solvers often combine deductive reasoning and exploration with learning and pattern matching. In the recent years such combinations are also increasingly developed for building stronger automated theorem provers, SMT solvers and conjecturing and synthesis systems.

The methods in this field include equipping the current deductive systems with efficient statistically learned guidance that controls the choice of the inference steps, using for example fast decision trees, graph neural networks and their combinations.

Learning and AI methods can also be used to automatically design new symbolic strategies for today's ATPs and SMTs. This has the advantage of producing explainable ideas for steering the search space, which can be further taken up and modified by the systems' developers.

I will also discuss several methods that try to directly synthesize reasoning objects such as instantiations and OEIS explanations, using various neural approaches.

Perhaps the most interesting aspect of this research are the positive feedback loops between the proving and the learning methods. I will show that some of them can today go quite far and create quite interesting "alien" solutions.