Logic Puzzle Solving with Natural Language Processing and Automated Reasoning

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Logic puzzles like the famous Einstein's Puzzle have become popular as a tempting and sometimes intricate challenge to humans' mind. On the one hand, they require precise language understanding to make mathematical sense out of textual clues. On the other hand, logical reasoning is needed to connect the individual clues and put them together to an overall solution. Humans possess these diverse skills and combine them, even without consciously distinguishing different ways of thinking.

While they are vastly superior to human thinking in terms of computational performance, no existing AI method—neither symbolic nor sub-symbolic—can reliably solve logic puzzles on its own. In particular, Large Language Models (LLMs), which achieve impressive results regarding the generation of meaningful texts, lack a conceptual model of the problem at hand and essentially guess rather than construct a claimed solution. Symbolic methods, such as Answer Set Programming (ASP), provide automated reasoning means to solve the underlying mathematical problem with ease, but require formal instead of natural language specifications.

In this group project, we aim to bring the strengths of sub-symbolic and symbolic AI methods together for integrating natural language processing with automated reasoning capabilities. On the specific task of solving logic puzzles, we will explore how LLMs can be used to extract the information required for reasoning with ASP systems. Relevant questions to be addressed include:

- What's the mathematical meaning of common textual clues and can one characterize them in terms of suitably chosen general classes of constraints?
- How can classes of constraints be encoded in the formal language of ASP such that the specification can be reused for solving different logic puzzles?
- Can an LLM and ASP system support one another for diagnosing and correcting possible misinterpretations of textual clues' mathematical meaning?

The outcome of this project shall be a prototype infrastructure that integrates natural language processing and automated reasoning to solve diverse logic puzzles in a systematic manner. In contrast to the sole use of LLMs, we hope to find solutions more efficiently and reliably, while also making the mathematical meaning of textual clues explicit for explanation. Compared to the application of ASP systems only, we expect to save tedious manual efforts of bringing logic puzzles into a formal representation, where automation should likewise be advantageous to avoid upfront or resolve on the fly any errors in the understanding of text clues.