Finite automata: selected problems and applications connecting different areas

Finite automata are one of the simplest computational models in computer science. Such automaton stores only its current state from a finite number of allowed states and its behavior is determined by an array of transitions between the states.

Applications of automata have an interdisciplinary character. They are used, for example, to model various devices, electronic circuits, schemes of behavior, or simple algorithms. They are significant in many engineering areas, molecular biology, linguistics, and even philosophy. Often, they are used in programming (e.g., in compilers, network protocols, data compression).

Finite automata play a fundamental role in theoretical computer science, appearing practically in all its areas. They also exhibit connections with many branches of mathematics (e.g., combinatorics, algebra, group theory, graph theory), thus mathematical methods are usually used to study them. Despite that the research on finite automata started a long time ago (as for computer science), still there are many unsolved problems.

In this project, we take up research aimed at solving a selected set of theoretical problems and using finite automata in the field of Artificial Intelligence. The motivation for this study is the further development of applied mathematical methods and the possibilities of applying automata in other areas.

One of the topics is the synchronization of automata, which is the problem of how quickly we can bring an automaton to a single known state, regardless of its current state; this field covers the still unsolved Černý conjecture from 1969 – one of the longstanding open problems in the theory of automata. We will study, for instance, new approaches, such as new quantities characterizing synchronizing automata, and also the synchronization problem in subclasses of automata important from the perspective of coding theory.

In Artificial Intelligence, we will apply automata for describing game rules in a formal way (or more generally: to represent problems of some type). We will enhance our previously designed language, inspired by theoretical concepts from automata theory. Then, we would like to use specific advantages of this representation to solve problems connected with one of the major challenges in this domain: creating an artificial intelligence playing well any given game / solve any given problem.

The expected effects of our studies are solutions for selected theoretical problems and development of applied mathematical methods. Although our study is basic research, the results may reveal new applications of automata.