On the Complexity of Intersection Non-Emptiness Problems

Doctoral Dissertation Defense

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December 1, 2016

1:00PM - 2:00PM
Davis Hall 203

Abstract

A central problem in formal language theory is deciding whether a finite list of regular languages has a non-empty intersection. That is, given a finite list of DFA's (deterministic finite automata), does there exist a string that satisfies all of the DFA's? This problem is known as the intersection non-emptiness problem for finite automata.

Intersection non-emptiness can be viewed as a constraint satisfaction problem. In particular, we can view each automaton as verifying some constraint. Then, determining if there exists a string that satisfies all of the automata is equivalent to determining if there exists a string that satisfies all of the constraints. Also, intersection non-emptiness can be viewed as a graph reachability problem. In particular, we can consider the Cartesian product of all of the automata. Then, determining if there exists a string that satisfies all of the automata is equivalent to determining if there exists a directed path from the start state to a final state in the product automaton.

The dual nature of intersection non-emptiness as both a constraint satisfaction problem and a graph reachability problem allows us to build parameterized reductions from fundamentally hard problems to intersection non-emptiness. These parameterized reductions allow us to characterize classical time and space complexity classes. In this thesis, we examine intersection non-emptiness problems for various kinds of automata in an effort to comprehensively characterize the classical time and space complexity classes.