

# Senior Thesis Abstract

Advisor: Christos Kapoutsis

Student: Qasim Nadeem

My senior thesis is regarding a topic in theoretical computer science. The relationship between deterministic and non-deterministic computation is an intriguing one and forms the basis of many important problems in Computer Science, most notably the 'P vs NP' question, which are unsolved. The comparison between determinism and non-determinism can be made in any model of computation. My thesis is concerned with this comparison on a very restricted computational model: finite automata. The thesis has two components.

The first component is trying to explore and understand the limitations of two-way finite automata (2FAs) - automata with finitely many states whose heads can move left or right on the input string- in particular, we are interested in their 'state' (also called 'descriptive') complexity. 'State' complexity of automaton is concerned with the question of how succinctly we can solve a problem using an automaton. Succinctness is measured in terms of the number of states an automaton has. The central open problem in this area is whether for every two-way non-deterministic finite automaton (2NFA)  $M$ , there exists an equivalent (recognizing the same language, or in other words solving the same problem) two-way deterministic finite automaton (2DFA) with only polynomially more states than  $M$ . This is denoted as the '2D vs 2N' question (comparing the 2

The second component of the thesis is related to working on a specific problem in this area. The problems called ONE-WAY LIVENESS and TWO-WAY LIVENESS are complete (in simple terms, they can be considered the 'hardest' problems in these sets) for 1N and 2N respectively. The upper and lower bounds on how succinctly these problems can be solved by 2DFAs are extremely far apart (bringing the bounds together for TWO-WAY LIVENESS for example would indeed answer the central question given in the previous paragraph). Our goal will be to improve the upper and lower bounds for these two problems on restricted inputs on 2DFAs, in the hope that this gives us valuable insight into the general unsolved problem. One way in which you can restrict the input, for example, is to only allow inputs of length 2, 3, 4 etc.