Model-Checking First-Order Logic: Automata and Locality

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The satisfaction problem for first-order logic, namely to decide, given a finite structure $\mathbb{A}$ and a first-order formula φ, whether or not $\mathbb{A} \models \varphi$ is known to be PSpace-complete. In terms of parameterized complexity, where the length of φ is taken as the parameter, the problem is AW[$\star$]-complete and therefore not expected to be fixed-parameter tractable (FPT). Nonetheless, the problem is known to be FPT when we place some structural restrictions on $\mathbb{A}$. For some restrictions, such as when we place a bound on the treewidth of $\mathbb{A}$, the result is obtained as a corollary of the fact that the satisfaction problem for monadic second-order logic (MSO) is FPT in the presence of such restriction [1]. This fact is proved using automata-based methods. In other cases, such as when we bound the degree of $\mathbb{A}$, the result is obtained using methods based on the locality of first-order logic (see [3]) and does not extend to MSO. We survey such fixed-parameter tractability results, including the recent [2] and explore the relationship between methods based on automata, locality and decompositions.

References

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