Z3-Noodler-Mocha at SMT Comp 2025

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I. Introduction

Z3-Noodler-Mocha is a derived tool built on *Z3-Noodler* [1]. *Z3-Noodler* is the winner of the QF_Strings division in the Single Query Track. However, we found that some optimization can significantly improve the performance of *Z3-Noodler*.

II. Z3-Noodler-Mocha

In this section, we introduce the core work of *Z3-Noodler-Mocha*. One optimization in *Z3-Noodler-Mocha* is based on the observation of automaton concatenation. Consistent with *Z3-Noodler* [1], we define the language $L(A)$ of the automaton A to be the set of all words for which A has an accepting run. Suppose there are n automata $A_1, A_2, ..., A_n$, we can get the following theorem, which is trivial to prove:

Theorem 1. $\forall 1 \leq i \leq n, L(A_i) \in w^* \implies \forall \sigma \in S_n, \text{concat}(A_1, A_2, \ldots, A_n) = \text{concat}(A_{\sigma(1)}, A_{\sigma(2)}, ... , A_{\sigma(n)})$

w is an arbitrary word and S_n denotes all possible permutations from 1 to n. For this equation constraint, existing solvers can easily prove that it is SAT, since the equality always holds. But it is difficult for them to prove that the corresponding inequality is UNSAT, which requires exhausting the entire search space. *Z3-Noodler-Mocha* proposed an optimization method dubbed *Lydon Optimization*, which is based on the KMP algorithm [2] and tries to find out whether $L(A) \in w^*$ holds and removes such constraints in the preprocessing stage.

Furthermore, according to the Lyndon–Schützenberger Theorem [3], we can conclude the following lemma:

Lemma 1. $\forall \sigma \in S_n, \text{concat}(A_1, A_2, \ldots, A_n) = \text{concat}(A_{\sigma(1)}, A_{\sigma(2)}, ..., A_{\sigma(n)}) \implies \forall 1 \leq i \leq n, L(A_i) \in w^*$

Without loss of generality, the optimization method used by *Z3-Noodler-Mocha* can effectively eliminate a class of constraints.

In addition, for constraints without variables, *Z3-Noodler-Mocha* uses some deterministic algorithms [4], [5] to speed up the decision procedures.

III. Acknowledgment

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