Pebble Transducers with Superpolynomial Growth

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Context: A pebble automaton is a 2-way device which can drop and lift a bounded number of marks, called pebbled, on its reading tape, with a so-called *stack discipline*: meaning that pebble number i cannot be moved while higher numbered pebbles are still on the tape. Pebble automata recognize the regular languages, and the restrictions 1) on the number of pebbles being bounded and 2) on the stack discipline are needed for that. While pebble automata are only as expressive as finite state automata, they can be far more succinct[1] and their computation time is in the worst case polynomial (of degree the number of pebbles) instead of linear.

Another big difference between finite state automata and pebble automata manifests when one considers transducers. A transducer is simply an automaton with outputs on its transitions. Most of the time, two different automata models will recognize the regular languages, yet their respective transducer counterparts will be incomparable. For instance 2-way transducers (which characterize the *regular functions*) can realize the copy function which copies a word twice, while a 1-way transducer cannot.

The class of functions defined by pebble transducers has been studied in [Boj18] and named *polyregular functions*, since they can have polynomial growth. This class enjoys many different characterizations, including an imperative programming language (**for** programs), a simple functional preogramming language and MSO string-to-string interpretations.

Objective: The goal of the internship is to go beyond polynomial growth, to exponential growth functions. Several automata models with potentially exponential length executions have been introduced, for instance, *marble* transducers or *invisible-pebble* transducers [EHS18].

The objective is to study these models, as well as other variants, and try to organize them in terms of expressiveness as well as understand their different compositional closure properties. For instance these models cannot be closed under composition from simple size agruments, however are they stable under composition with polyregular functions?

References

[Boj18] Mikołaj Bojańczyk. Polyregular functions. 2018.

[EHS18] Joost Engelfriet, Hendrik Jan Hoogeboom, and Bart Samwel. XML navigation and transformation by tree-walking automata and transducers with visible and invisible pebbles. 2018.

[1] Actually Tower-y more succinct