Derandomizing Isolation in the Space-Bounded Setting

Isolation is the process of singling out a solution to a problem that may have many solutions. It plays an important role in the design of efficient parallel algorithms as it ensures that the various parallel processes all work towards a single global solution rather than towards individual solutions that may not be compatible with one another. For example, the best parallel algorithms for finding perfect matchings in graphs hinge on isolation for this reason. Isolation is also an ingredient in some efficient sequential algorithms. For example, the best running times for certain NP-hard problems like finding Hamiltonian paths in graphs are achieved via isolation. All of these algorithms are randomized, and the only reason is the use of the Isolation Lemma -- that for any set system over a finite universe, a random assignment of small integer weights to the elements of the universe has a high probability of yielding a unique set of minimum weight in the system. For each of the underlying problems it is open whether deterministic algorithms of similar efficiency exist. This talk is about the possibility of deterministic isolation in the space-bounded setting. The question is: Can one always make the accepting computation paths of nondeterministic space-bounded machines unique without changing the underlying language and without blowing up the space by more than a constant factor? Or equivalently, does there exist a deterministic logarithmic space mapping reduction from directed st-connectivity to itself that transforms positive instances into ones where there is a unique path from s to t? I will present some recent results towards a resolution of this question, obtained jointly with Gautam Prakriya. Our approach towards a positive resolution can be viewed as derandomizing the Isolation Lemma in the context of space-bounded computation.

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