Summary: By considering nondeterminism as a quantifiable resource, we introduce new nondeterministic complexity classes obtained from NC circuits using a bounded number of nondeterministic gates. Let $\text{NNC}(f(n))$ denote the class of languages computable by an NC circuit family with $O(f(n))$ nondeterministic gates. If $f(n)$ is limited to $\log n$, we show that the class obtained is equivalent to NC. If $f(n)$ is allowed to encompass all polynomials, we show that the class obtained is equivalent to NP. The class of most interest, $\text{NNC}(\text{polylog})$, obtained by letting $f(n)$ encompass all polylogarithmic functions, contains a version of the quasigroup (Latin square) isomorphism problem. The quasigroup isomorphism problem is not known to be in P or NP-complete; thus, $\text{NNC}(\text{polylog})$ is a candidate for separating NC and NP.

We also show that $\text{NNC}(\text{polylog}) \subseteq \text{DSPACE}(\text{polylog})$. More specifically, we show that $\text{NNC}^k(\log^kn)$ is contained in $\text{DSPACE}(\log^kn)$, where $\text{NNC}^k(\log^kn)$ denotes the complexity class obtained from an NC$^k$ circuit with $O(\log^kn)$ nondeterministic gates. This containment yields DSPACE($\log^2n$) algorithms for the quasigroup isomorphism problem, the Latin square isomorphism problem and the Latin square graph isomorphism problem. The only previously known bound for these problem is Miller’s time bound of $n\log^2n + O(1)$. This result also generalizes the DSPACE($\log^2n$) algorithm of R. J. Lipton, L. Snyder and Y. Zalcstein [“Complexity of the word and isomorphism problems for finite groups”, in: Proc. Conf. Inf. Sci. Syst. 10, 33-35 (1976)] for the group isomorphism problem. We also show that, for every $k$, $\text{NNC}(n^k) \subseteq \text{DSPACE}(n^k)$, and if for some $k$ there exists a $j$ such that DSPACE($n^k$) \subseteq NNC($n^j$) then NP=PSPACE.


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