Neural Termination Analysis

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We introduce a novel approach to the automated termination analysis of computer programs: we use neural networks to represent ranking functions. Ranking functions map program states to values that are bounded from below and decrease as a program runs; the existence of a ranking function proves that the program terminates. We train a neural network from sampled execution traces of a program so that the network's output decreases along the traces; then, we use symbolic reasoning to formally verify that it generalises to all possible executions. Upon the affirmative answer we obtain a formal certificate of termination for the program, which we call a neural ranking function. We demonstrate that thanks to the ability of neural networks to represent nonlinear functions our method succeeds over programs that are beyond the reach of state-of-the-art tools. This includes programs that use disjunctions in their loop conditions and programs that include nonlinear expressions.