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(57) Abstract :

A computer-implemented system exploiting the synergy between machine learning and graph theory is disclosed. A graph construction module represents a technical system, such as a communication network, integrated circuit, molecule, or process plant, as an attributed graph. A graph-theoretic analysis engine computes exact structural invariants, including spectral quantities, connectivity and flow measures, substructure and motif counts, automorphism information, and decomposition parameters, incrementally and with reported bounds for estimated quantities. A machine learning engine, comprising graph neural and value, policy, and strategy models, receives these invariants as features, overcoming the known expressive limits of message passing, and emits solution-quality assessments and search priorities. A coupling controller operates both engines in a bidirectional loop, restricting admissible actions so outputs are structurally valid by construction, and confining learned influence to search ordering and incumbent initialization so classical optimality guarantees are preserved while running time falls. Technical outputs with structural explanations are applied to the system, and retained instances retrain the models continually.

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