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Half-trek criterion for generic identifiability of linear structural equation models

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A linear structural equation model relates random variables of interest and corresponding Gaussian noise terms via a linear equation system. Each such model can be represented by a mixed graph in which directed edges encode the linear equations and bidirected edges indicate possible correlations among noise terms. We study parameter identifiability in these models, that is, we ask for conditions that ensure that the edge coefficients and correlations appearing in a linear structural equation model can be uniquely recovered from the covariance matrix of the associated distribution. We treat the case of generic identifiability, where unique recovery is possible for almost every choice of parameters. We give a new graphical condition that is sufficient for generic identifiability and can be verified in time that is polynomial in the size of the graph. It improves criteria from prior work and does not require the directed part of the graph to be acyclic. We also develop a related necessary condition and examine the "gap" between sufficient and necessary conditions through simulations on graphs with 25 or 50 nodes, as well as exhaustive algebraic computations for graphs with up to five nodes.

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