"When causation does not imply correlation: robust violations of the Faithfulness axiom"

I took down the public copy of this paper in June 2012 because it's currently under submission to a journal. If you would like a copy, email me and ask.

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Meanwhile, here is the abstract:

Current methods of inferring causal information from correlational data assume that causation implies correlation: that whenever there is a causal connection between two variables, their correlation must be non-zero. More precisely, it is claimed that a zero correlation in the presence of causal influences can only arise by the unlikely chance (a chance with probability zero) of multiple causal connections between the two variables exactly cancelling out. This is the Faithfulness axiom.

We exhibit two counterexamples to this axiom: classes of systems in which Faithfulness is violated, and robustly so: no small variation of parameters will make the relevant correlations non-zero. These systems exhibit correlations indistinguishable from zero between variables that are strongly causally connected, and very high correlations between variables that have no direct causal connection, only a connection via causal links between uncorrelated variables. The first example is that of a bounded differentiable variable and its first derivative, or a discrete time series and its first difference. The second example is control systems. Control systems have a systematic tendency to produce low or zero correlations between variables that are physically directly connected, together with very high correlations between variables whose only causal connections are indirect, proceeding via those low-correlation links. That this is even possible may sound paradoxical, but it is inherent in the way that these systems operate.

All of these counterexamples violate one of more of the preconditions required for various published methods of causal inference to be applied. There is thus no contradiction of those results, but a limitation of their scope.

The counterexamples are not of any artificially contrived sort. On the contrary, the equations defining them and physical systems exemplifying them are commonplace, especially in the life sciences, and to that extent, this must have implications for the conduct of causal analysis in this area.