Using Self-Modeling Networks to Model Adaptive Causality

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Abstract: Causal modeling is an intuitive, declarative way of modeling that due to the universal character of causality in principle applies to practically all disciplines. In spite of this seemingly very wide scope of applicability, there are also serious limitations and challenges that stand in the way of applicability, in particular when dynamics and adaptivity play a role. This paper addresses these challenges by exploiting the notion self-modeling network developed from a Network Science perspective. It is shown how temporal-causal networks allow modeling dynamics based on a given network of causal relations and how any causal network can be extended to a self-modeling network to also model dynamic changes of the causal relations themselves. In this way, self-modeling causal networks are obtained that show dynamics of the states of the nodes based on the causal relations as well as adaptivity of these causal relations. Adaptivity is obtained by adding self-models to a given causal base network; these self-models represent the base network's causal structure by additional network nodes for the causal relations that are adaptive. The obtained self-modeling causal networks are themselves temporal-causal networks as well, are still specified in a declarative manner by mathematical relations and functions, and create a next level for the causal network by which the adaptation is addressed. Moreover, this construction can easily be iterated so that multiple orders of adaptation can be covered in the form of multilevel causal models, for example, addressing controlled adaptation or both plasticity and metaplasticity. So, this indeed takes causal modeling to a next level in more than one way so that now dynamics and adaptivity are also covered well, which substantially widens the scope of applicability of causal modeling.