Faithful Model Inversion Substantially Improves Auto-encoding Variational Inference

Stefan Webb, Adam Goliński, Robert Zinkov, Yee Whye Teh, Frank Wood

Correspondence to: `stefan.webb@eng.ox.ac.uk`

UNIVERSITY OF OXFORD

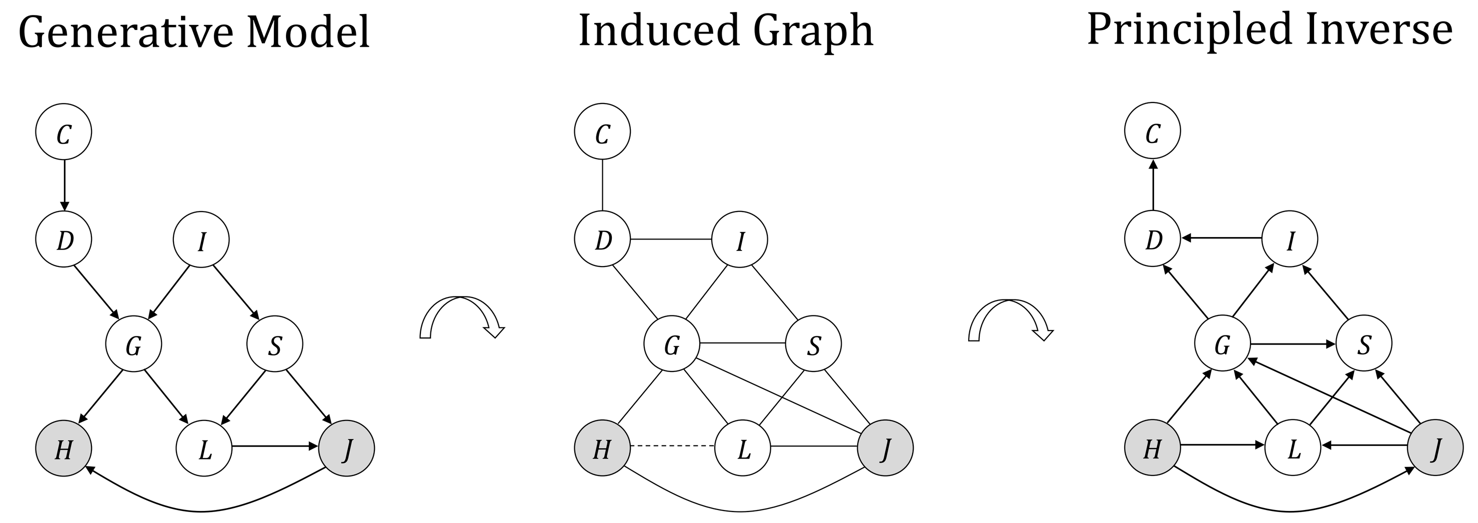
Abstract

- Our chief insight is that *the d-separation properties of the directed graphical model (DGM) structure of the forward model should be used to produce an encoder factorization that is faithful to the posterior*, in the sense that it does not impose independencies not present in the true posterior
- Auto-encoding variational inference requires the design of an encoder for learning either the model and/or the posterior
- Typically, the structure of the encoder is formed in an ad hoc way by simply reversing the edges in the DGM of the generative model
- We introduce a novel algorithm that given the factorization for a generative model, produces a faithful factorization for the posterior that is optimal in a certain technical sense

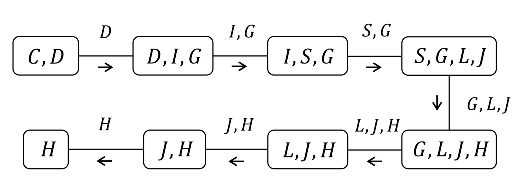
The CoMI Algorithm

INPUT: A graph for the forward model, and set of observed variables

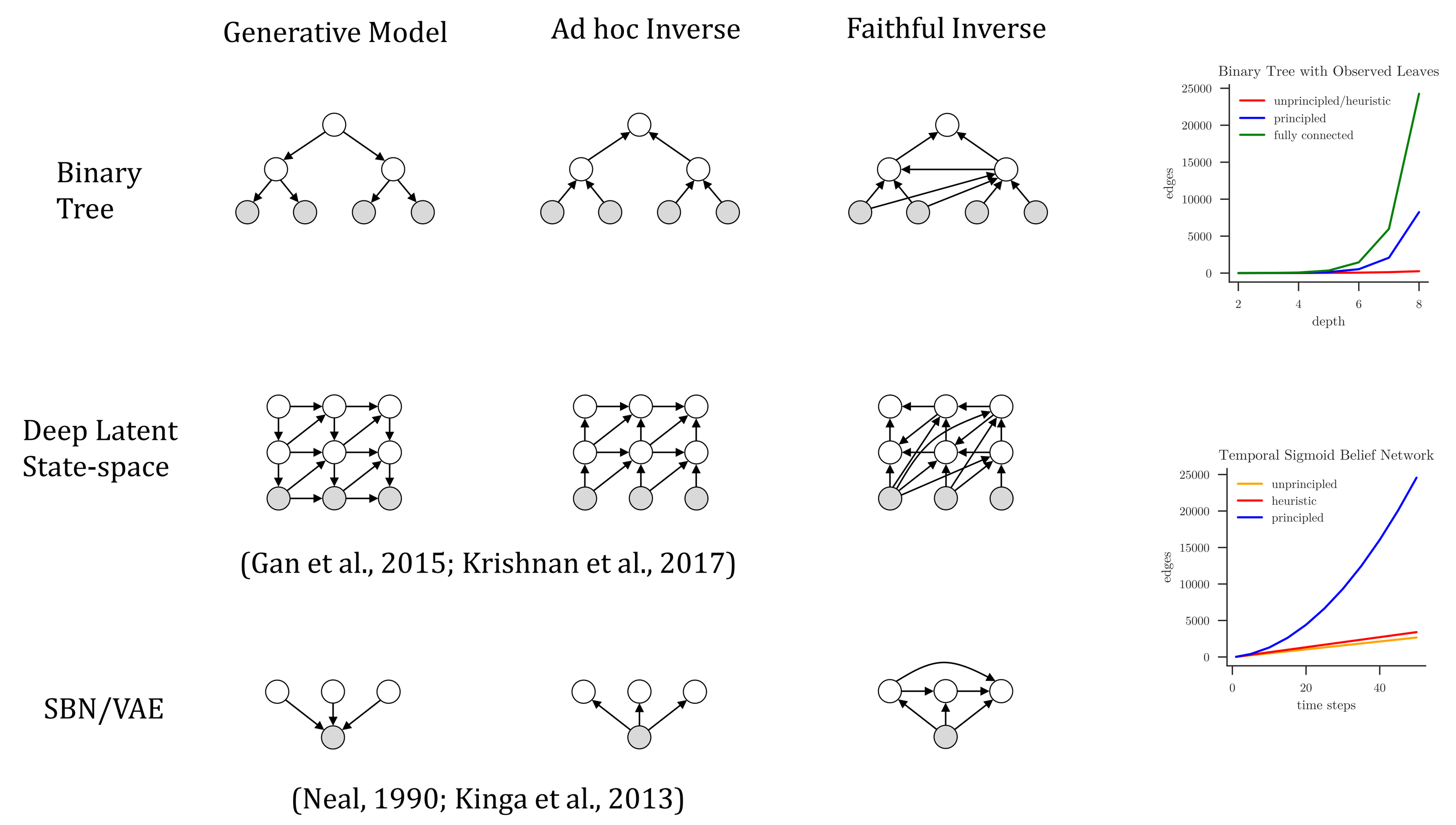
OUTPUT: A compact minimal I-map for the inverse model



- Simulates variable elimination (Koller and Friedman, 2009) on the forward model, eliminating latent variables first, then observed
- Chooses the elimination ordering by combining a topological ordering on the forward model with a min-fill heuristic
- The sepset property of the corresponding clique tree, equivalent to the induced graph, allows to us construct the inverse factorization



Some Examples



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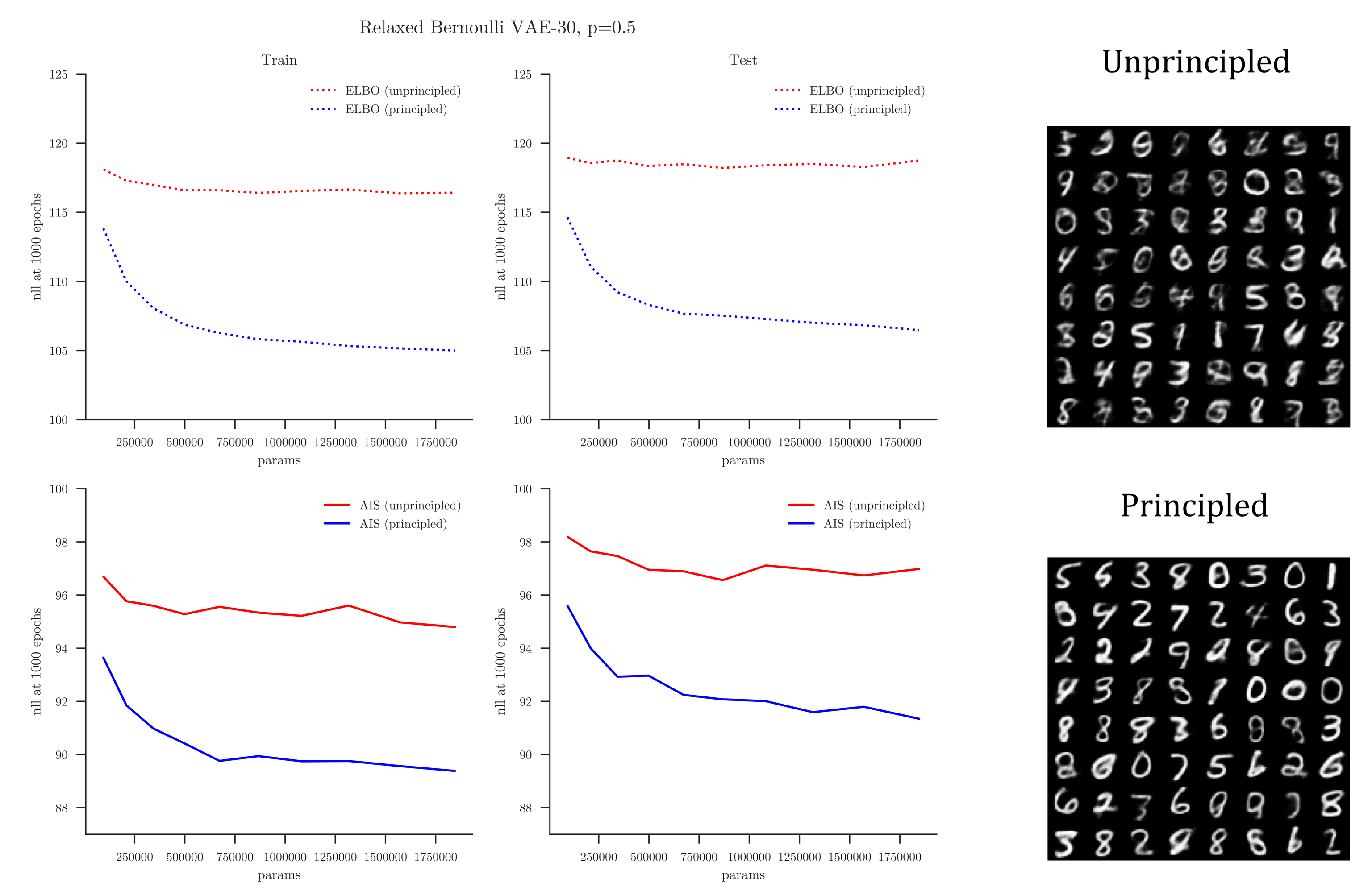
AIMS Autonomous Intelligent Machines & Systems

EPSRC Engineering and Physical Sciences Research Council

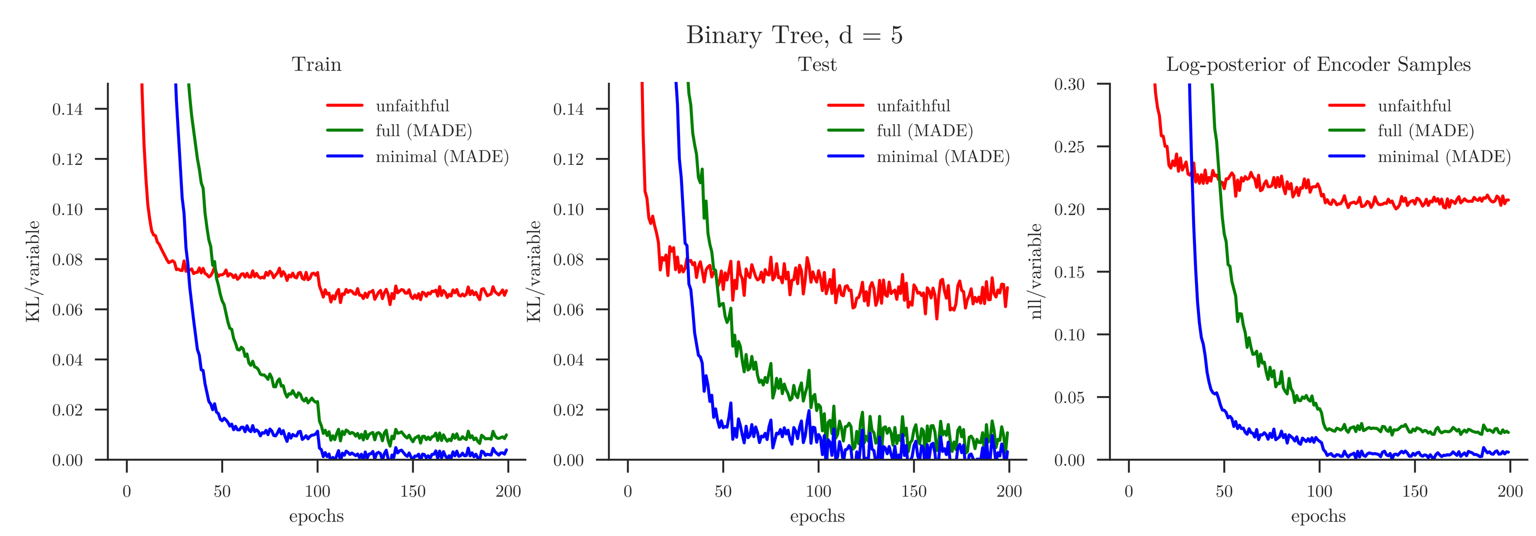
DARPA

Faithful Encoders Appear to Improve Model Learning



- A faithful encoder outperforms an ad hoc one *at every capacity level*
- After 10,000 epochs, reaches 86.5 nats, equivalent to results from an unfaithful encoder with 200 latent units and a multi-sample objective with 50 importance weighted samples (Maddison Et Al., 2016; Jang et al., 2016)

Faithful Encoders Recover the True Posterior



- The unfaithful encoder is unable to learn the true posterior
- A fully connected MADE encoder (Germain et al., 2015) and an encoder based on a novel MADE variant for trees (both faithful, the later minimal) are able to learn the posterior
- The minimally faithful encoder learns quicker than the fully connected one. Why?

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