Feedback Message Passing for Inference in Gaussian Graphical Models

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While loopy belief propagation (LBP) performs reasonably well for inference in some Gaussian graphical models with cycles, its performance is unsatisfactory for many others. In particular for some models LBP does not converge, and in general when it does converge, the computed variances are incorrect (except for cycle-free graphs for which belief propagation (BP) is non-iterative and exact). In this paper we propose {\em feedback message passing} (FMP), a message-passing algorithm that makes use of a special set of vertices (called a {\em feedback vertex set} or {\em FVS}) whose removal results in a cycle-free graph. In FMP, standard BP is employed several times on the cycle-free subgraph excluding the FVS while a special message-passing scheme is used for the nodes in the FVS. The computational complexity of exact inference is $O(k^2n)$, where k is the number of feedback nodes, and n is the total number of nodes. When the size of the FVS is very large, FMP is intractable. Hence we propose {\em approximate FMP}, where a pseudo-FVS is used instead of an FVS, and where inference in the non-cycle-free graph obtained by removing the pseudo-FVS is carried out approximately using LBP. We show that, when approximate FMP converges, it yields exact means and variances on the pseudo-FVS and exact means throughout the remainder of the graph. We also provide theoretical results on the convergence and accuracy of approximate FMP. In particular, we prove error bounds on variance computation. Based on these theoretical results, we design efficient algorithms to select a pseudo-FVS of bounded size. The choice of the pseudo-FVS allows us to explicitly trade off between efficiency and accuracy. Experimental results show that using a pseudo-FVS of size no larger than $\log(n)$, this procedure converges much more often, more quickly, and provides more accurate results than LBP on the entire graph.

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