Graphical models provide a convenient method of describing probabilistic distributions and statistical dependency in such a way as to enable the development of relatively simple exact or approximate inference algorithms. Perhaps the best known of these algorithms is belief propagation (BP), which formulates an exact procedure for marginalization in simple (cycle-free, or tree-structured) systems in such a way that it can be easily applied to more complex problems. Although this has often resulted in great success in such problem domains as turbo and LDPC decoding, computer vision, machine learning, and sensor networks, on these more complex problems so-called "loopy" BP is no longer guaranteed to converge to a unique solution. Variations such as quantization, message censoring, and other approximations (which often arise in distributed sensor networks) are also poorly understood.

Intuition and empirical findings tell us that loopy BP will be well-behaved on problems which are tree-like, and that there are several factors which may contribute to this being the case. By performing a stability analysis of BP we can quantify many of these notions and derive powerful sufficient conditions for convergence; these conditions appear to be tight for at least a subset of problems. Moreover, the framework in which this analysis is performed makes it possible to draw many additional conclusions, including bounding the number of iterations required to achieve a given precision or analyzing the behavior of quantized, censored, or otherwise modified BP-like algorithms.

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