

On Correctness of Belief Propagation for Ising Markov Random Field Model

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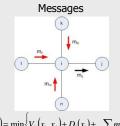
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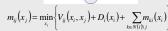
1. Introduction

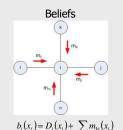
- •Belief propagation is an algorithm for inference in graphical models
- •In networks with loops results are approximate and convergence becomes a problem
- •Nevertheless, it has been successfully applied to turbo codes and computer vision tasks
- •We applied loopy belief propagation as inference engine for image denoising algorithm previously developed in our group
- •Each wavelet band is modelled as Markov Random Field (MRF)
- •The goal is to detect whether there is a signal of interest at certain location and to use the posterior probability as shrinkage factor for denoising

2. Loopy Belief Propagation

•Iteratively applies update rules:







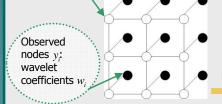
3. Detection of Signal of Interest Using Ising MRF Model

MRF definition

 $x_i = -1$ absence of a signal of interest

Binary hidden nodes:

 $x_i = 1$ presence of a signal of interest. Metropolis $\phi_i(x_i, y_i) = p(y_i = w_i | x_i)$



Local evidence:

Pairwise potential: $V_{ij}(x_i, x_j) = -\gamma x_i x_j$ Neighborhood potential:

 $V_{N(i)}(x_i) = \sum_{j \in N(i)} V_{ij}(x_i, x_j)$

Data cost: $D_i(x_i) = -\log(p(y_i = w_i|x_i))$

Pairwise potential: $V_{ii}(x_i, x_i) = -\gamma x_i x_i$

Inference

Starts from initial mask Metropolis and iteratively updates labels based on:

$$r = \frac{p(y_i|x_i^C)}{p(y_i|x_i)} \exp(V_{N(i)}(x_i) - V_{N(i)}(x_i^C))$$

Starts from unbiased messages and iteratively applies update rules from 2

Output

Binary mask of labels representing edge map and posterior probabilities

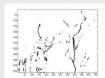
$$p(x_i = 1 | y_i = w_i)$$

4. Results

Binary mask for vertical component of edges



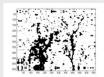
Ground truth



Metropolis



Sequential LBP, γ =0.1



Parallel LBP, γ =0.1



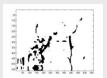
Parallel LBP, γ =0.3

5. Possible Improvements

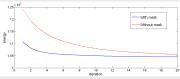
- Redefine spatial prior so it has more flexibility
- Simple experiments:



1. Increasing γ in each iteration



2. Biasing messages with initial mask



Total energy comparison of LBP with biased (experiment 2) and unbiased messages (standard)