Maximum likelihood separation of spatially auto-correlated images using a Markov model

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Abstract

We recently proposed an efficient maximum likelihood approach for blindly separating markovian time series [1]. In the present paper, we extend this idea to bi-dimensional sources (in particular images), where the spatial correlation of each source is described using a 2nd-order Markov model. The idea of using Markov Random Fields (MRF) for image separation has recently been exploited by other authors [2], where the source Probability Density Functions (PDF) are supposed to be known, and are used to choose the Gibbs priors. In the present work, however, we make no assumption about the source PDF so that the method can be applied to any sources. Beginning with the joint PDF of all the observations, and supposing a unilateral 2nd-order Markov model for the sources, we can write down the likelihood function and show that the nondiagonal entries of the separating matrix can be estimated by solving the following estimating equations

$$E[\sum_{k=0}^{1} \sum_{l=-1,k+l\neq -1}^{1} \psi_{\hat{s}_i}^{(k,l)}(m,n)\hat{s}_j(m-k,n-l)] = 0 \qquad i \neq j$$

where the conditional score functions $\psi_{\hat{s}_i}^{(k,l)}$ of the estimated sources $\hat{s}_i$ are

$$\psi_{\hat{s}_i}^{(k,l)}(m,n) = \frac{-\partial \log P_{s_i}(\hat{s}_i(m,n)|\hat{s}_i(m-1,n-1),\hat{s}_i(m-1,n),\hat{s}_i(m-1,n+1),\hat{s}_i(m,n-1))}{\partial s_i(m-k,n-l)}$$

In practice, these functions must be estimated from data in a 5-dimensional space. The nonparametric estimation algorithm used in [1] being very time consuming, we developed a new algorithm using polynomials as score function parametric models. The estimating equations were solved using Newton algorithm. The experiments proved the better performance of our method in comparison to some classical algorithms. The final version of the paper will contain the theoretical details and the experimental results with artificial and real data including astrophysical images.

References:

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