Proposed Method: Correlated Tensor Factorization (CTF)

An ultimate approach to nonnegativity-based tensor decomposition that includes as its special cases nonnegative matrix factorization (NMF), positive semidefinite tensor factorization (PSDTF), and nonnegative tensor factorization (NTF)

Cost function

- Nonnegative Matrix Factorization (NMF)
  \[ C_{NMF}(X|Y) = \sum_{t=1}^{T} \frac{1}{F} \sum_{f=1}^{F} D(x_{ft}|y_{ft}) \]

- Positive Semidefinite Tensor Factorization (PSDTF)
  \[ C_{PSDF}(X|Y) = \sum_{t=1}^{T} \frac{1}{F} \sum_{f=1}^{F} D(\hat{x}_{ft}|\hat{y}_{ft}) or \sum_{t=1}^{T} \frac{1}{F} \sum_{f=1}^{F} D(x_{ft}|y_{ft}) \]

- Correlated Tensor Factorization (CTF)
  \[ C_{CTF}(X|Y) = D(X|Y) \]

Parameter estimation (majorization-minimization algorithm)

- IS-NMF
  - Cost function
  - Complexity: \( O(KF^2T^2) \)

- PSDTF
  - Complexity: \( O(KF^3T^3) \)

- CTF
  - Complexity: \( O(KF^3T^3) \)

Joint diagonalization of basis matrices

- PSDTF in the time-frequency domain is equivalent to IS-NMF in a linearly-transformed domain if W's and H's can be jointly diagonalized by using the transform matrices

Estimation result of \( (P, Q) = (64, 20) \)

Evaluation and Future Work

A mixture signal was synthesized by concatenating 7 sounds (C4, E4, G4, C4+E4, C4+G4, E4+G4, C4+E4+G4) (16 kHz), 1.2 [s] \( \times 7 = 8.4 \) [s], F=256, T=840)

IS-NMF and estimation of transform matrices could be iterated in a unified probabilistic framework to approximate CTF

Related work: independent vector analysis (IVA) (Jiro 2011).

Independent low-rank matrix analysis (IRMA) (Kumata 2016)

Computationally-Efficient Approximation of CTF

Block-diagonalization of basis matrices

The time-frequency domain is divided into independent blocks each of which consists of \( P \) frequency bins and \( Q \) time frames (the TF bins of a block are correlated with each other and independent from the other TF bins)

Estimation result of \( (P, Q) = (64, 20) \)