Robust Unmixing Algorithms for Hyperspectral Imagery

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1. Introduction

Hyperspectral imagery

- Same scene observed at different wavelengths
- Pixel represented by a vector of hundreds of measurements

Robust non-negative matrix factorization (RNMF) [1]

- Observation model: \( y_n = MA_n + e_n \)
- Assumptions:
  - Positive basis vectors: \( A \)
  - Gaussian additive noise: \( e \)

Robust Bayesian linear unmixing (RBLU) [2]

- Observation model: \( y_n = MA_n + \phi \) with \( \phi \sim \mathcal{N}(0, \Sigma) \)
- Assumptions:
  - Basis vectors: \( A \) are independent
  - Support: \( S \) is spatially-spectrally sparse and correlated

RCA with model mismoding effects (RCA-ME) [3]

- Observation model: \( y_n = MA_n + d_n + e_n \) with \( e_n \sim \mathcal{N}(0, \Sigma) \) and a diagonal covariance \( \Sigma = \text{diag}(\sigma^2) \)
- Assumptions:
  - Positive basis vectors: \( A \)
  - Support: \( S \) is spatially-spectrally correlated

2. Models and algorithms

General formulation

- Residual component analysis model (RCA)
  - \( y_n = f(Ma_n + \phi) \)
- \( M = [m_1, \ldots, m_g] \) matrix of endmembers
- \( a_n \geq [a_{g1}, \ldots, a_{gG}] \) abundance vector
- \( \phi \) residual component
- \( f(\cdot) \): function introducing noise (additive, Gaussian, Poisson, ...)

Robust Bayesian concept.

- A real image acquired by the Defence Science and Technology Laboratory (DSTL) in 2014 over Porton Down, U.K.
- Contains 400 x 200 pixels, \( L = 140 \) bands in [415, 990] nm, \( R = 5 \) components with other man-made outliers.

3. Results on a real image

Data description and evaluation criteria

- A real image acquired by the Defence Science and Technology Laboratory (DSTL) in 2014 over Porton Down, U.K.
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Real Porton Down image.

Abundance maps

- Estimated abundance maps with different algorithms (grey scale range between 0 and 1): from left to right: green, blue, red, and red, and wil 2.

Quantitative results

- Mean, RMSE, and SAM values for different algorithms.

4. Discussion

- The robust algorithms detect man-made outliers
- Complementary results in terms of the detected physical effects, computational time and estimation quality.

References