Thermal and Multispectral Imaging

Lecture 5: Hyperspectral analysis

Jörgen Ahlberg

LINKÖPING UNIVERSITY

Repetition of some concepts from Lecture 1-4

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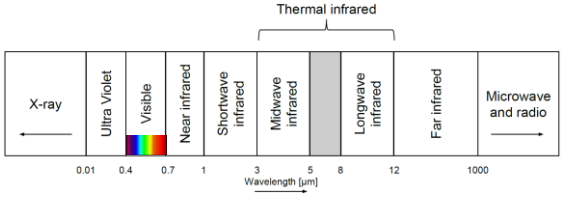
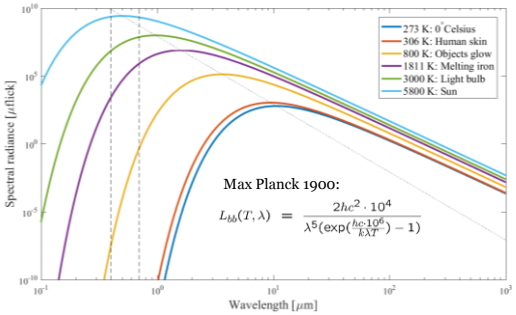
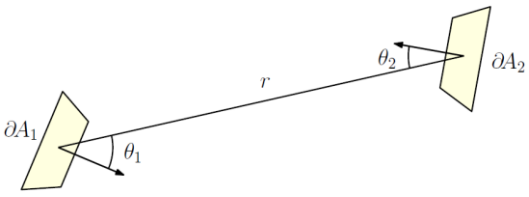
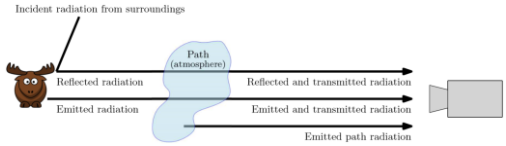
Domains and wavelengths and bands





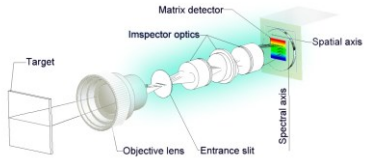
Radiative transfer



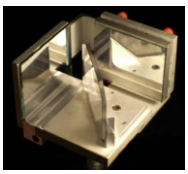


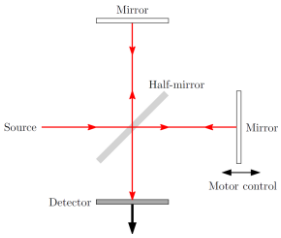
Hyperspectral cameras

Dispersive cameras

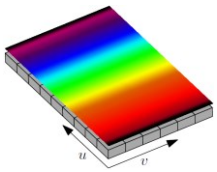


Interferometer



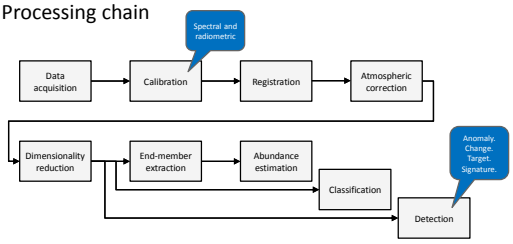


Linear variable optical band-pass filter (LVF)



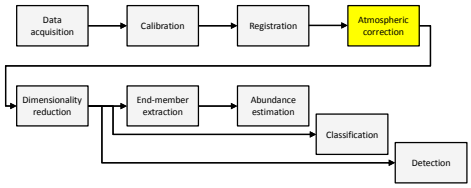
Hyperspectral processing chain

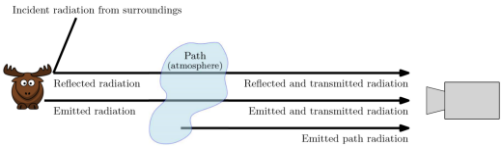
Processing chain

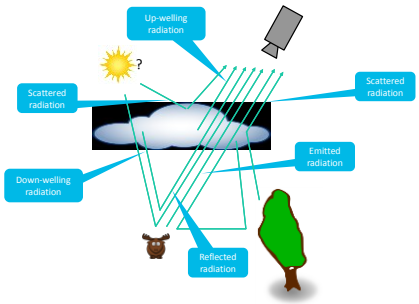


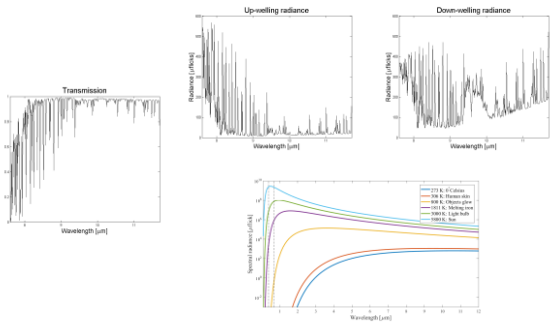
Atmosphere

Processing chain





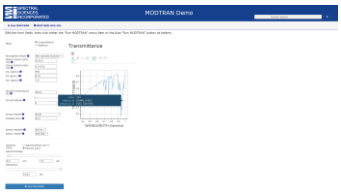




Important concepts & problems

- Water column / column water
- Aerosols
- Cloud masks

Simulations



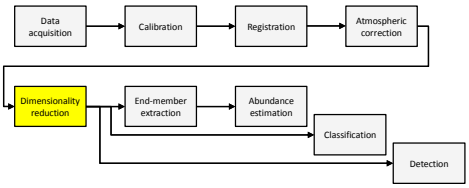
http://modtran.spectral.com/modtran_home

Atmospheric correction

- Exploit known signatures in the image (ELM)
- In-scene methods
  - Simulation based: AFRL/SSI
  - QUAC
  - FLAASH

Dimensionality reduction

Processing chain



Dimensionality reduction: Why?

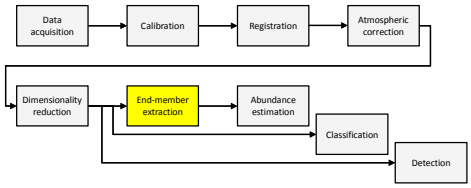
- Correlation
- Visualization
- Feature extraction
- Complexity
- Noise
- Unmixing

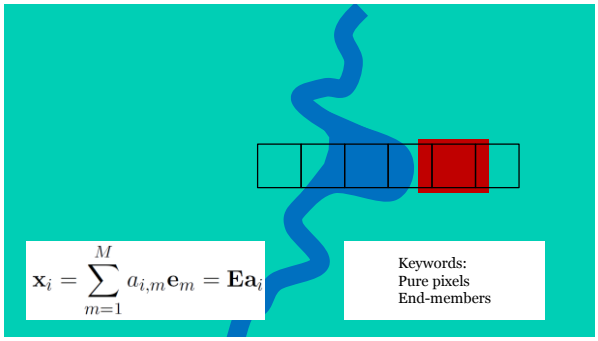
Dimensionality reduction: How?

- Extraction
  - PCA
  - MNF
  - kPCA
  - Manifold learning
  - Learning vector quantization
  - Deep features
  - Autoencoders
- Selection
  - Search procedures
  - Search criteria

Spectral unmixing

Processing chain

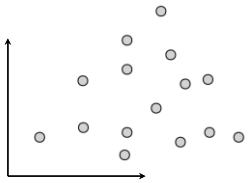




$$\mathbf{x}_i = \sum_{m=1}^{M} a_{i,m}\mathbf{e}_m = \mathbf{E}\mathbf{a}_i$$

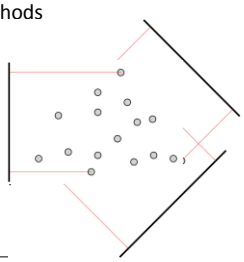
Keywords:
Pure pixels
End-members

Which are the end-members?



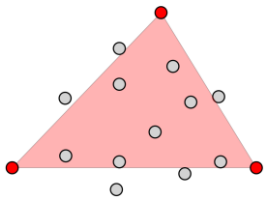
End-member extraction methods

- Pure Pixel Search



End-member extraction methods

- Pure Pixel Search
- Simplex Volume Maximization



N-FINDR

Algorithm 1 The N-FINDR algorithm for end-member extraction

Input: K N-dimensional vectors $\{\mathbf{x}_i\}_1^K$.

Pick $M = N + 1$ (random) samples $\mathbf{e}_1 \ldots \mathbf{e}_M$.

Let $\mathbf{E}^* \leftarrow \begin{bmatrix} 1 & \cdots & 1 \\ \mathbf{e}_1 & \cdots & \mathbf{e}_M \end{bmatrix}$.

Let $V(\mathbf{E}^*) = \frac{1}{(N-1)!}|\mathbf{E}^*|$.

for $i = 1, \ldots, K$ **do**

  for $m = 1, \ldots, M$ **do**

    Let $\mathbf{E}_m = \begin{bmatrix} 1 & \cdots & 1 & 1 & 1 & \cdots & 1 \\ \mathbf{e}_1 & \cdots & \mathbf{e}_{m-1} & \mathbf{x}_i & \mathbf{e}_{m+1} & \cdots & \mathbf{e}_M \end{bmatrix}$.

    if $V(\mathbf{E}_m) > V(\mathbf{E}^*)$ **then**

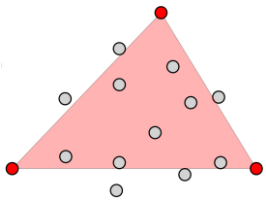
      Let $\mathbf{E}^* = \mathbf{E}_m$.

    end if

  end for

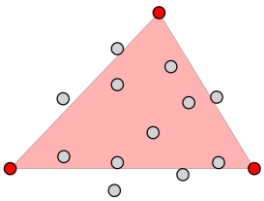
end for

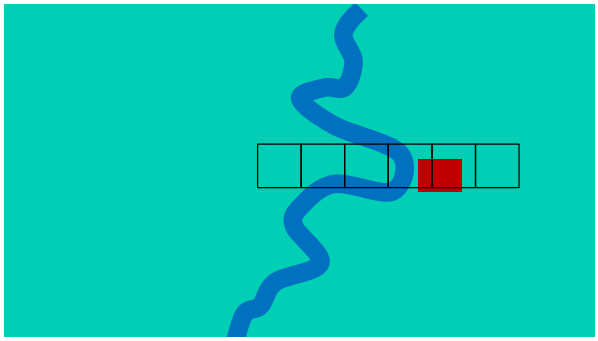
Output: The last N rows of $\mathbf{E}^*$ contains the end-members.



End-member extraction methods

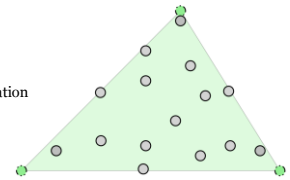
- Pure Pixel Search
- Simplex Volume Maximization
  - Cone Volume Maximization (SMACC)





End-member extraction methods

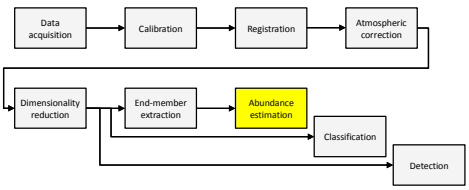
- Pure Pixel Search
- Simplex Volume Maximization
  - Cone Volume Maximization
- Simplex Volume Minimization
  - Non-negative matrix factorization

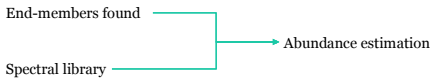


End-member extraction methods

- Pure Pixel Search
- Simplex Volume Maximization
  - Cone Volume Maximization
- Simplex Volume Minimization
  - Non-negative matrix factorization
- Sparse regression methods

Processing chain





Alternative mixing models

- Intimate mixing models (IMM)
- Bi-linear mixing models
- Polynomial mixing models

Next lecture

- Unmixing methods: Gustav.
- Quick atmosphere correction (QUAC): Karl.