Tecniche di ultima generazione per l’analisi automatica di immagini iperspettrali satellitari

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- Feature Selection for HSI images
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Introduction

• Improvements in spectral resolution of hyperspectral images (HSIs) requires advances in signal processing and exploitation algorithms, opening the doors to new application domains.

• HSI images are typically characterized by:
  ▪ high dimensionality of the pixels;
  ▪ high spectral redundancy;
  ▪ heterogeneities at subpixel level;
  ▪ impact of atmospheric and geometric distortions;
  ▪ spatial variability of the spectral signature;
  ▪ nonlinear feature relations.

• All of these factors, together with few labeled samples typically available, make HSI image processing a complex problem. Moreover, high computational time is required for the analysis of large images (Big Data challenge).

Picture from http://www.evolved-analytics.com/?q=technology/courses/featureselection
System Architecture of HSI Image Processing

Pre-processing

Radiometric Normalization → Mosaiking → Noise Reduction

Pre-processed hyperspectral images

Radiometric normalized hyperspectral mosaic

Classification/Regression

Feature Extraction → Feature Selection → Automatic Classification

Automatic Regression

Thematic Maps

Biophysical Parameters

M radiometric normalized hyperspectral images

$X_1$ M hyperspectral images

$X_M$
• The high dimensionality of HSI images, as well as the high redundancy among spectral bands, can compromise the classification/estimation results.

• Feature extraction methods allow the identification of the most discriminative variables for data classification, regression, clustering, ranking, compression, or data visualization.

• In many situations, nonlinear feature extraction is necessary to obtain an acceptable performance. This is a very complex problem when few labeled data points are available.

Feature Selection for HSI images

• The high dimensionality of the feature space with respect to the typical small amount of labeled training samples represents one of the main challenges of the automatic processing of HSI images.

• Feature selection methods select a subset of original features more informative for the desired application. In this context, we developed feature selection methods to:
  ▪ select the most informative spectral channels for image classification [2];
  ▪ select the most significant filter parameters to extract spatial information from the scene [3];
  ▪ detect the set of features that minimize the distributions distance between different HSI images for domain adaptation [4].


**Example – Feature Selection for Classification**

**Study Area:** Bosco Fontana (Mantova, Italy)
- Extension: 233 ha;
- 23 forest species.

**HSI data:**
- Six partially overlapping images;
- Acquisition date: 28th June 2006;
- Sensor: AISA Eagle;
- Spectral Channels: 126;
- Spectral Range: 400-990 nm;
- Spectral Resolution: 4.6 nm;
- Spatial Resolution: 1 m;
- Flight Height: 750 m.

**False Color HSI image**

**Kappa Accuracy:** 87.90%

**Thematic Map**

Example – Feature Selection for Classification

Example – Classification over the Venice Lagoon

**Study Area:** Venice Lagoon (Venice, Italy)

- Six classes;

**HSI data:**

- Sensor: ROSIS;
- Spectral Channels: 115;
- Spectral Range: 400-990 nm;
- Spatial Resolution: 1 m;

**Overall Accuracy:** 89.37%

 Regression for Biophysical Variable Estimation

• The estimation of biophysical parameters is of special relevance in order to understand better the environment dynamics at local and global scales.

• To accurately estimate the biophysical parameters, sophisticated methods are needed to capture the relationships between remote sensing measurements and the investigated parameters.

• In this framework, we developed advanced regression methods in order to:
  
  ▪ define specific cost functions that can handle the different types of noise [7];
  
  ▪ address regression problems with small size initial training data [8].


Fusion of HSI images and other RS data

Pre-processing

Radiometric Normalization

Mosaiking

Noise Reduction

Co-registration

Feature Extraction

Feature Selection

Automatic Classification

Thematic Maps

M hyperspectral images

$X_1$

$X_M$

$M$ hyperspectral images

$X_1$

$X_M$

$M$ radiometric normalized hyperspectral images

Hyperspectral mosaic

LiDAR data

DEM

Intensity

Height

Pre-processing

RS

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Development of an automatic system based on hyperspectral and LiDAR data for forest monitoring and management.
Conclusion

• An overview of some of the methods and applications for the automatic analysis of the HSI images developed by the Rslab team (University of Trento) has been presented.

• The presented system architecture for HSI image processing is based on:
  ▪ Feature Extraction for HSI images;
  ▪ Feature Selection for HSI images;
  ▪ Classification of HSI images;
  ▪ Regression of Biophysical Parameters with HSI images.

• An example of integration of HSI images with other RS data has been presented.

• The proposed system architecture can be applied in different application domains and is promising for PRISMA HSI images processing.
Thank you for the attention!