Mapping Crop Type using Hyperspectral and Multispectral Datasets

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Flow of Presentation

- Introduction
- Study Area
- Satellite Datasets
- Methodology
- Results and Discussion
- Conclusion
Introduction

Imaging spectrometry (spectroscopy) began in the early 1980’s

- **Commercial**: mineral exploration, agriculture and forest production
- **Atmosphere**: water vapor, cloud properties, aerosols
- **Ecology**: chlorophyll, leaf water, cellulose, pigments
- **Geology**: mineral and soil types
- **Snow/Ice**: snow cover fraction, grain size, melting
- **Coastal Waters**: chlorophyll, suspended sediments
- **Biomass Burning**: sub-pixel temperatures, smoke

Source: www.ccrs.nrcan.gc.ca/ccrs/misc/issues/hyperview_e.html
Introduction

Each spatial element has a continuous spectrum that is used to analyze the surface and atmosphere.

224 spectral images taken simultaneously.

Source: http://uregina.ca/piwowarj/Satellites/Hyperspectral.html
Introduction

**Multispectral**

- Pixel Has Discrete Spectral Bands
- MED: Multispectral: several to tens of bands

**Hyperspectral**

- Pixel Has Continuous Spectrum
- HIGH: Hyperspectral: hundreds of narrow bands
Introduction

Figure 1: Spectral signatures from hyperspectral vs. multispectral sensors.

Source: ITRES
Objectives

- Develop methodology for atmospheric correction of Hyperspectral data
- Classification of Hyperspectral data using Spectral Angle Mapper (SAM) classification
- Assessing of the potential of Hyperspectral data for mapping crops and other land cover feature using Multispectral image as reference.
District Larkana and its nearby area is selected for this study.

In the month of September, Rice is the major Kharif crop in that area.

Additionally, Guava orchards are also located in the east.
Satellite Datasets

Specification of images used in this study are:

**Image specification of Hyperion data**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Location</th>
<th>Scene No.</th>
<th>Acquisition date</th>
<th>Spectral Resolution</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Larkana (27.559720 N, 68.212780 E)</td>
<td>152-41</td>
<td>22 Sep, 2002</td>
<td>242</td>
<td>30m</td>
</tr>
</tbody>
</table>

**Image specification of Landsat ETM+ data**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Location</th>
<th>Scene No.</th>
<th>Acquisition date</th>
<th>Spectral Resolution</th>
<th>Spatial Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Larkana (27.559720 N, 68.212780 E)</td>
<td>152-41</td>
<td>06 Sep, 2002</td>
<td>7</td>
<td>30m (Band 1-5,7) 60 m (Band 6)</td>
</tr>
</tbody>
</table>
Methodology

- Spectral sub-setting and calibration of Hyperion image
- Geometric Correction of Hyperion and Landsat image
- Atmospheric Correction of Hyperion and Landsat images
- Bad band removal from Hyperion data
- End-member extraction from both data types
- Comparison between SAM classification using Multispectral and Hyperspectral data
Out of 242 bands, Hyperion acquire data in 196 bands. Because of this reason spectral sub-setting was done in the first step.

For radiometric calibration VNIR bands were divided by 40 whereas SWIR bands were divided by 80 as directed in user manual of Hyperion data sets.
Hyperion data was geometrically corrected using ENVI image registration tool.

Landsat ETM image was used as referenced image.

Projection : UTM, Zone 42 North
Cell size : 30 Meters
Datum : WGS-84
Resampling : Nearest Neighbor Method
Atmospheric Correction using FLAASH

Atmospheric correction of the 196 channels of Hyperion dataset was performed by using FLAASH (Fast Line-of-Sight Atmospheric Analysis of the Spectral Hypercubes).
Bad Band Selection

- Atmospheric water vapor bands have vertical stripping that are usually identified by visual (Beck R et al., 2003).

- For this reason, the subset of 129 selected bands incorporated for SAM classification are listed in Table I.

Table 1: List of selected 129 bands used for this research

<table>
<thead>
<tr>
<th>Array</th>
<th>Bands</th>
<th>Wavelength (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VNIR</td>
<td>5-46</td>
<td>467.52 – 884.7</td>
</tr>
<tr>
<td></td>
<td>55-68</td>
<td>972.99 – 1104.12</td>
</tr>
<tr>
<td>SWIR</td>
<td>74-90</td>
<td>1164.68 – 1326.05</td>
</tr>
<tr>
<td></td>
<td>107-135</td>
<td>1497.63 – 1780.09</td>
</tr>
<tr>
<td></td>
<td>160-171</td>
<td>2032.35 – 2143.34</td>
</tr>
<tr>
<td></td>
<td>176-190</td>
<td>2193.73 – 2335.01</td>
</tr>
</tbody>
</table>

End-member Extraction

- Theoretically the existing pure features in mixed pixels are referred to as end-members.
- Field based spectral libraries for end-member extraction were unavailable.
- Image based spectral libraries were used for SAM classification.
- A window of 3 x 3 pixels was used for the extraction of spectral end-members of each feature.
Crop type - Orchard

This spectral library include the Guava plantation in the east of District Larkana, Sindh.
Crop type – Seasonal 1

This spectral library include the Seasonal agriculture in the south-east of District Larkana, Sindh.
Crop type – Seasonal 2

This spectral library include the Seasonal agriculture in the north-west of District Larkana, Sindh
This spectral library include the waterlogged area in the north-east of District Larkana, Sindh.
Canal water

This spectral library include the Fresh water passing through District Larkana, Sindh
Settlements

This spectral library include settlements in District Larkana, Sindh.
This spectral library include barren land at the south-east of District Larkana, Sindh.
End-member Extraction

Multispectral data
End-member Extraction

Hyperspectral data
In this study, the Spectral Angle Mapper (SAM) classification is applied for crop type mapping. The Spectral Angle Mapper (SAM) is a physically-based spectral classification that uses an n-dimensional angle to match pixels to reference spectra [Kruse et al., 1993].

Comparison between Hyper and Multi spectral data

Comaprisong of Hyperspectral and Multispectral Data

Hyperspectral data  Multispectral data  Unclassified Image

Map Name: Thematic map using SAM technique
Date: 26-02-2013
Source: Hyperion-EO1 and Landsat_162_041
Study area: Larkana
Date of Acquisition: 22-09-2002 and 08-09-2002
Map Projection: WGS84 UTM Zone 42N
Produced By: R&D App. Div.
Comparison between Hyper and Multi spectral data

Hyperspectral data

Multispectral data

Unclassified image
Comparison between Hyper and Multi spectral data
Comparison between Hyper and Multi spectral data

Hyperspectral data

Multispectral data
Conclusion

- It is concluded that FLAASH (Fast Line-of-Sight Atmospheric Analysis of the Spectral Hypercubes) is an efficient method for atmospheric correction of Hyperspectral data.

- Same spatial resolution, same methodology, different classification results due to different spectral resolution.

- Mixing of classes is rare in Hyperspectral data as compared to Multispectral data.
Thanks
Atmospheric Correction using FLAASH
To remove disturbances by the atmosphere digital numbers (DN) are converted to at-satellite radiance based on the gain (Lmax) and bias (Lmin) for each band (Markham and Barker, 1986), which were provided from image header file.

\[ L_{\lambda_{\text{sensor}}} = \left( \frac{L_{\text{max}} - L_{\text{min}}}{Q_{\text{calmax}}} \right) \times Q_{\text{cal}} + L_{\text{min}} \]

Where,

- \( L_{\lambda_{\text{sensor}}} \): Spectral Radiance at the sensor’s aperture In W/(m^2.sr. \mu m)
- \( Q_{\text{cal}} \): The quantized calibrated pixel value in Digital Number (DN)
- \( Q_{\text{calmax}} \): The maximum quantized calibrated pixel value (DN=255) corresponding to Lmax
- \( L_{\text{min}} \): The spectral radiance that is scaled to Qcalmin in W/(m^2.sr. \mu m)
- \( L_{\text{max}} \): The spectral radiance that is scaled to Qcalmax in W/(m^2.sr. \mu m)
Atmospheric Correction

The use of reflectance instead of radiances results into two advantages.

- First, the cosine effect of different solar zenith angles due to the time difference between data acquisitions can be removed, and
- Second, it compensates for different values of the exoatmospheric solar irradiances arising from spectral band differences.

\[ \rho_p = \frac{\pi x L_\lambda x D^2}{E_{SUN\lambda} x \cos (\theta_{zenith})} \]

Where,

- \( \rho_p \): Unitless planetary reflectance
- \( L_\lambda \): Spectral radiance at the sensor's aperture
- \( D \): Earth-Sun distance in astronomical units
- \( E_{SUN\lambda} \): Mean solar exoatmospheric irradiances
- \( \theta_{zenith} \): Solar zenith angle in degrees