Forest type discrimination using multi-angle hyperspectral data

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Objectives

Discrimination of forest stand type on the basis of:

- **Species composition**
  - Coniferous
    - Spruce group
  - Broadleaved
    - Pine group

- **Stand structure**
  - Stand density, height, crown size
CHRIS-PROBA data potential

Species composition -> Hyperspectral capability

Stand structure <-> Multiple view angle capability
Study site (Beauraing site)

Nismes forest (Couvin, Belgium)
(50°00’N; 4°34’E)
Data sets

• Colour orthophotos → GCPs for CHRIS images geocoding

• Forest stand parameters:
  species composition, age, basal area, density, height

  Collected during field campaign or extracted from the forest management plan
## Data sets

### Reference forest stand description

<table>
<thead>
<tr>
<th>Code</th>
<th>Species</th>
<th>Age</th>
<th>Density (N.ha(^{-1}))</th>
<th>Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYO</td>
<td>Spruce</td>
<td>10</td>
<td>2860</td>
<td>5</td>
</tr>
<tr>
<td>CME</td>
<td>Spruce</td>
<td>26</td>
<td>2140</td>
<td>15</td>
</tr>
<tr>
<td>CMA</td>
<td>Spruce</td>
<td>90</td>
<td>360</td>
<td>25</td>
</tr>
<tr>
<td>BME</td>
<td>Oak, birch</td>
<td>n.a.</td>
<td>540</td>
<td>20</td>
</tr>
<tr>
<td>BMA</td>
<td>Oak</td>
<td>n.a.</td>
<td>250</td>
<td>25</td>
</tr>
<tr>
<td>BMA2</td>
<td>Oak, birch</td>
<td>n.a.</td>
<td>160</td>
<td>25</td>
</tr>
</tbody>
</table>
CHRIS-PROBA data

CHRIS data:

- Acquired on April 09th, 2003 @ 10:50 UT
- 5 images (FZA : +55°, +36°, 0°, -36°, -55°)
- 18 spectral bands/image (mode 4)

Acquisition geometry parameters (view angles) obtained from the orbit propagation model (using WXtrack package and TLEs)
CHRIS-PROBA data – Acquisition geometry
CHRIS images (09 April, 2003)  R-G-B : 785 nm - 672 nm - 551nm
Data exploration - Deciduous stands

DMA

DMA1

DMA2

DME

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Data exploration - Deciduous stands

DMA

DMA1

DMA2

DME

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Data exploration - Coniferous stands
Angular signature analysis

What is the real contribution of the directional effect for discriminating forest stand type?

1. On the basis of the TOA radiance (includes the spectral effect)
Angular signature analysis

\[ \lambda = 551 \text{ nm} \]
Angular signature analysis

\[ \lambda = 716 \text{ nm} \]

\[ \lambda = 785 \text{ nm} \]
Angular signature analysis

2. On the basis of an anisotropy index (isolating the directional effect)

$$DRI(\Theta, \Phi, \lambda) = \frac{\sum \sum R(\Theta, \Phi, \lambda)}{\sum \sum \sum \sum R(\Theta, \Phi, \lambda)}$$

![Graph showing anisotropy index vs fly-by zenith angle](image)
Statistical analysis

Testing three effects on the radiance:

- forest type
- view angle
- wavelength

Coniferous stand and deciduous stands were analysed separately because the discrimination between coniferous and deciduous stands is straightforward in the near-infrared bands.

As expected, the main effects were highly significant ($\alpha=0.01$)
Statistical analysis

Testing effect of:

forest type, view angle and their interaction for each spectral band separately.

As expected, the main effects were again highly significant.

The interaction was significant for 15 bands (exceptions: 489, 551, 742 nm in the deciduous stand pool).

This means that the different forest stands show differentiated spectral response depending on the view angle.
Statistical analysis

A pairwise comparison of mean radiance of the interaction effect allowed to identify the means which were actually significantly different.

Radiances of the different forest stand types are compared for each angle.
Statistical analysis

In coniferous stands:

- on the basis of a single view angle data, e.g. the near-nadir image, the radiance means were significantly different for several bands.

- one view angle multispectral data are sufficient to discriminate the three coniferous stand types.
Statistical analysis

In deciduous stands:

• The radiance mean of the middle-aged stand was significantly different from the radiance mean of the two mature stands at many wavelength in the near-nadir image.

• But the radiance means of the low density and the high density mature stands were significantly different only in the +36° image at 2 wavelengths (716, 785nm).

• The multiple view angle data were essential in this case.
Conclusion

- Most of the six forest types could be discriminated on the basis of the near-nadir spectral signature alone.

- The multiple view angle data could be relevant in differentiating some forest types, typically those having different stand densities.

- It seems that the proportion of sensed shadow, casted to the background, has a major influence on the reflectance directional anisotropy.

- A summer image is however needed to confirm this.