Classification of Multisensor Images With Different Spatial Resolution

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Outline

- Classification task definition from multisensor data
- Design of separate classifiers
- Proposed data fusion approach
- Results and conclusions
Processed images

• Data presented to 2014 IEEE GRSS Data Fusion Contest by Telops Inc., Canada:
  • RGB image with ground truth for 7 land use categories
  • LWIR image in 84 bands from 7.8 μm to 11.5 μm
RGB image

Spatial resolution 0.2m

Categories:
- road
- trees
- red roof
- grey roof
- concrete roof
- vegetation
- bare soil
LWIR image band 10

Spatial resolution ~1m
The task

- Classification of high resolution pixels into land use categories
- Focusing on data from one overflight
- Design set = test set

Targets:
- Exploiting data from both sensors
- Fast method
- High overall accuracy
- Independent from image contents
Approach

- Assumption: pixels of a category are random variables with multidimensional Gaussian distribution (in both images)
- Calculate parameter estimates for each category $j$, for both images. E.g. for RGB:

$$\mu_j = (\mu_{j1}, \mu_{j2}, \mu_{j3})^T$$

$$\Sigma_j = \frac{1}{c_j - 1} \sum_{v=1}^{c_j} (x_v - \mu_j) \cdot (x_v - \mu_j)^T$$

$c_j$ - number of pixels within ground truth area

$$x_v = (x_{v1}, x_{v2}, x_{v3})^T$$ - intensity vector of a pixel
Bayes classifier of RGB pixels

- Probability density for category $j = 1, 7$

$$f_j(x) = (2\pi)^{-3/2} |\Sigma_j|^{-1/2} \exp\left(-1/2 (x - \mu_j)^T \Sigma_j^{-1} (x - \mu_j)\right)$$

- Classification rule $W^*$: if $f_k(x)/f_j(x) \geq 1$ for each $j$, pixel with intensity vector $x$ is classified as pixel of category $k$

- By taking logarithm from the expression and denoting the square of the Mahalanobis distance by $M_j(x) = (x - \mu_j)^T \Sigma_j^{-1} (x - \mu_j)$

we change the rule to: $M_j(x) - M_k(x) \geq \ln \frac{\Sigma_k}{\Sigma_j}$

* Equal prior probabilities assumed
Selection of bands in LWIR image

The following statistical parameters explored

- Entropy\(^1\)
- Optimum index factor \((OIF)^2\)

By means of Entropy and \(OIF\), 50 bands were dismissed, 8 from other 34 were selected manually (using bands from the whole range, not using neighbors).

- Selected bands: 4, 14, 26, 36, 47, 57, 69, 78

**Further work needed**

Classifier of LWIR pixels

- Intensity vectors of pixels: \( \mathbf{y} = (y_1, y_2, \ldots, y_8)^T \)
- Parameters: mean vector \( \mathbf{\mu}'_j = (\mathbf{\mu}'_{j1}, \mathbf{\mu}'_{j2}, \ldots, \mathbf{\mu}'_{j8})^T \)
  covariance \( \mathbf{S}_j = \frac{1}{c'_j - 1} \sum_{\nu=1}^{c'_j} (\mathbf{y}_\nu - \mathbf{\mu}'_j) \cdot (\mathbf{y}_\nu - \mathbf{\mu}'_j)^T \)

where \( c'_j \) - number of pixels within ground truth area in LWIR

- Probability density:
  \[ g_j(\mathbf{y}) = (2\pi)^{-8/2} |\mathbf{S}_j|^{-1/2} \exp\left(-1/2 (\mathbf{y} - \mathbf{\mu}'_j)^T \mathbf{S}_j^{-1} (\mathbf{y} - \mathbf{\mu}'_j)\right) \]

- Classification rule \( V \): if \( g_k(\mathbf{y}) / g_j(\mathbf{y}) \geq 1 \) for each \( j \), pixel with intensity vector \( \mathbf{y} \) is classified as pixel of category \( k \)

- Changed:
  \[ M'_j(\mathbf{y}) - M'_k(\mathbf{y}) \geq \ln \frac{|\mathbf{S}_k|}{|\mathbf{S}_j|} \]
Combined classifier

• For each pixel $x$, define associated pixel with intensity vector $y^a$

• Classification rule $U$: if

$$M_k(x) + M'_{k}(y^a) \leq M_j(x) + M'_j(y^a) - \ln \frac{\Sigma_k}{\Sigma_j} - \ln \frac{S_k}{S_j}$$

for each $j$, pixel with intensity vector $x$ is classified as pixel of category $k$
# Results

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<tr>
<th>User's accuracy, %</th>
<th>$W$</th>
<th>$W'$</th>
<th>$V$</th>
<th>$V'$</th>
<th>$U$</th>
<th>$U'$</th>
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<td>53</td>
<td>92</td>
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<td>trees</td>
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<td>94</td>
<td>38</td>
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<td>94</td>
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<tr>
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<td>97</td>
<td>48</td>
<td>31</td>
<td>99</td>
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<tr>
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<td>94</td>
<td>57</td>
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<td>96</td>
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<tr>
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<td>96</td>
<td>19</td>
<td>59</td>
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<td>96</td>
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<tr>
<td>vegetation</td>
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<td>84</td>
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<td>34</td>
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<td>Overall accuracy, %</td>
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Error matrix

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<th>trees</th>
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<th>gray roof</th>
<th>concrete</th>
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<th>bare soil</th>
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Conclusions

• Proposed combination approach of separate classifiers is fruitful

• Proposed combined classifier seems simple and straightforward for implementation
Further work

• Explore different multidimensional distributions

• Consider clustering within defined categories

• Develop a method for choosing informative bands in LWIR image

• Develop an approach for classification of pixels related with different overflights with classifiers designed from ground truth from one overflight
Thank you for attention!

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