

EXAMINATION OF REMOTE SENSING

Last name: _____, First name: _____


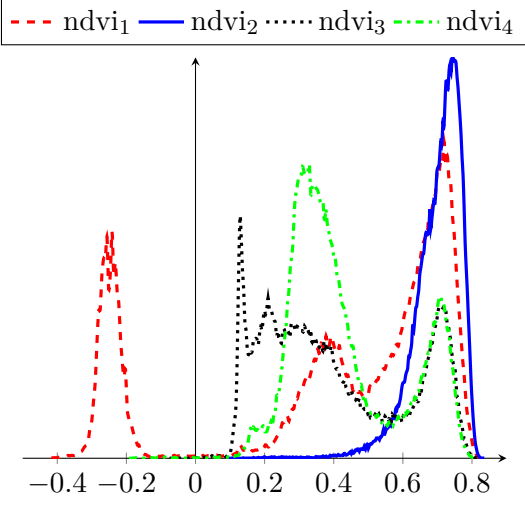
2013-2014

The matlab files should be send at the end of the exam to *mathieu.fauvel@ensat.fr* and should be named *{lastname_function*.m}*

1 Multiple choice questions (/6 pts)

+1pt for right answer, -0.5pt for false answer and 0pt for no answer. One right response by question.

Questions	a	b	c	d	pts
<div style="text-align: center;"> </div> <p>1. On the above figure, the unit of wavelength is: a=<i>nm</i>, b=<i>cm</i>, c=<i>μm</i>, d=<i>mm</i>.</p> <p>2. In the figure of question 1, which is the spectrum that corresponds to woody vegetation? a=<i>s₁</i>, b=<i>s₂</i>, c=<i>s₃</i>, d=<i>s₄</i>.</p> <p>3. In the figure of question 1, which is the spectrum that corresponds to shadow? a=<i>s₁</i>, b=<i>s₂</i>, c=<i>s₃</i>, d=<i>s₄</i>.</p>					

Questions	a	b	c	d	pts																																											
 <p style="text-align: center;">Image</p>  <p style="text-align: center;">Histogram of NDVIs</p> <p>4. On the above figure, which is the histogram that corresponds to the histogram of the NDVI computed on the left color image? a=ndvi₁, b=ndvi₂, c=ndvi₃, d=ndvi₄.</p>																																																
<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="5">Ground Truth</th> </tr> <tr> <th>Forest</th> <th>Bare soil</th> <th>Vegetation</th> <th>Water</th> <th>Built up</th> </tr> </thead> <tbody> <tr> <th rowspan="5" style="writing-mode: vertical-rl; transform: rotate(180deg);">Thematic Map</th> <th>Forest</th> <td>39168</td> <td>0</td> <td>370</td> <td>0</td> <td>3</td> </tr> <tr> <th>Bare soil</th> <td>0</td> <td>8612</td> <td>427</td> <td>0</td> <td>1238</td> </tr> <tr> <th>Vegetation</th> <td>3</td> <td>0</td> <td>10264</td> <td>0</td> <td>596</td> </tr> <tr> <th>Water</th> <td>1607</td> <td>0</td> <td>4</td> <td>27272</td> <td>262</td> </tr> <tr> <th>Built up</th> <td>0</td> <td>3932</td> <td>929</td> <td>0</td> <td>1628</td> </tr> </tbody> </table> <p>5. The number of pixels referenced as <i>vegetation</i> but classified as <i>bare soil</i> is a=0, b=10264, c=427, d=8612.</p> <p>6. The overall accuracy for the above confusion matrix is a = 100%, b=90.3%, c=30.4%, d=74.9%.</p>			Ground Truth					Forest	Bare soil	Vegetation	Water	Built up	Thematic Map	Forest	39168	0	370	0	3	Bare soil	0	8612	427	0	1238	Vegetation	3	0	10264	0	596	Water	1607	0	4	27272	262	Built up	0	3932	929	0	1628					
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2 Regularized Gaussian Mixture Model (10 pts)

In remote sensing a conventional estimator for the covariance matrix of class i for a Gaussian mixture model is [Lan03]:

$$\hat{\Sigma}_i = (1 - \alpha)\mathbf{S}_i + \alpha \text{diag}(\mathbf{S}_i) \quad (1)$$

where \mathbf{S}_i is the sample covariance matrix : $\frac{1}{n_i} \sum_{j=1}^{n_i} (\mathbf{x}_j - \hat{\boldsymbol{\mu}}_i)(\mathbf{x}_j - \hat{\boldsymbol{\mu}}_i)'$, n_i the number of samples of class i , $\hat{\boldsymbol{\mu}}_i$ the empirical mean of class i and α a regularization parameter such as $0 \leq \alpha \leq 1$.

In the following, σ_{ij} denotes the variance of band j for class i and λ_{ij} denotes the eigenvalue j of the covariance matrix of class i ; λ_{i1} corresponds to the largest eigenvalue and λ_{id} corresponds to the smallest eigenvalue.

- For $\alpha = 1$, what is the associated probabilistic model for class i ?

2. For $\alpha = 0$, what is the associated probabilistic model for class i ?

3. Write the literal expression of the condition number for the different values of α .

α	0	1
$\kappa(\hat{\Sigma}_i)$		

4. Implement the regularization with matlab (training, cross_validation and testing). Apply it on the two data sets (multispectral and hyperspectral): plot the overall accuracy in function of the parameter using the cross-validation technique and select the optimal value of α .

3 Histogram stretching with saturation (/4 pts)

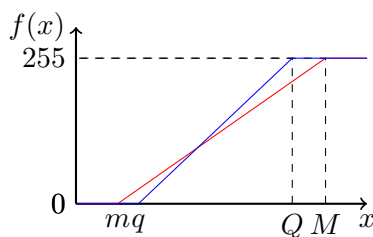


Figure 1: Histogram stretching.

In the lab-work 1, for the visualization of color composition, you have stretched the data between 0 and 255 using the following function:

$$f(x) = 255 \times \frac{(x - m)}{M - m}.$$

This approach is sensitive to noise and not optimal in term of contrast enhancement since the maximum and minimum of the spectral channel can be outliers of the true distribution of image.

In this work, you will implement the following stretching function (see figure 1):

$$f(x) = \begin{cases} 255 & \text{if } x > Q \\ 0 & \text{if } x < q \\ 255 \times \frac{(x-q)}{Q-q} & \text{otherwise} \end{cases}.$$

Q and q will be computed so that the 2th percentile and 98th percentile of the data range are not considered. The matlab function `prctile` will be useful.

Write a matlab function with input arguments the image and the three bands to visualize.

Percentile [Wikipedia]: *A percentile is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall. For example, the 20th percentile is the value (or score) below which 20 percent of the observations may be found. The term percentile and the related term percentile rank are often used in the reporting of scores from norm-referenced tests. For example, if a score is in the 86th percentile, it is higher than 86% of the other scores. The 25th percentile is also known as the first quartile, the 50th percentile as the median or second quartile, and the 75th percentile as the third quartile. In general, percentiles and quartiles are specific types of quantiles.*

References

[Lan03] D.A. Landgrebe. *Signal Theory Methods in Multispectral Remote Sensing*. John Wiley and Sons, New Jersey, 2003.