Estimating LAI Using Vegetation Indices

Quantitative remote sensing of biophysical parameters

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Preparation

In this exercise, we will use a software system for technical computations called Matlab. If you have not yet installed Matlab on your computer, please do so.

Data

You may copy the folder "measured" from the network in your computer. Needed files for this exercise are:

samples.mat
lai.mat
wl.mat

For further information, please see the articles which are provided on the network by Darvishzadeh et al. 2011, Darvishzadeh et al. 2009 and of course the Matlab help.

Outline

Leaf Area Index (LAI) measures one-half of the total leaf area of the vegetation per unit area of soil (background) surface. Field measurements of this variable over larger areas are time-consuming, hence expensive. Remote sensing data have been used for its cost-effective, rapid, reliable, and objective estimation to study this variable. To minimize the variability due to external factors such as underlying soil brightness and leaf optical properties, remote sensing data have been transformed and combined into various vegetation indices (VI). Spectral vegetation indices are usually calculated as combinations of near-infrared and red reflectance. The aim of this exercise is to understand and examine a few vegetation indices for estimating LAI. The performance of these vegetation indices will be compared using R^2 and RMSE obtained from Linear regression models.

Data Exploration

Start MATLAB software through the MATLAB-Icon. MATLAB contains five windows: usually command window in the center, workspace, and command history on the left side of the screen and on the right side of the screen folders, and the details of files are demonstrated.

☞Change your current directory to where you have copied the data by browsing it from the menu bar on top.

The folder contains three files. "samples.mat" contains spectral reflectance data measured in 584 wavelengths by a hyperspectral sensor for 60 grassland plots. These spectral data are presented in the form of a matrix (584*60).
"wl.mat" is an array with the wavelengths names of the hyperspectral sensor.
"lai.mat" contains the measured field LAI for each plot.

☞Load the matrices by entering the "load" command in the command window or by double-clicking the matrices in the current folders windows

Load samples
Load lai
Load wl

In Matlab always a matrix is defined by its row and columns. In our case, the matrix of reflectance is 584* 60. This means that the reflectance data is measured in 584 wavelengths (as rows) for 60 grass plots (as columns).
The matrix of LAI is a one-dimensional array and is called a vector. It contains the measured LAI of 60 grassland plots.

☞You can now explore the data by calculating their statistics. For example for the lai which is the LAI data of the grassland plots type in the command window:

Minlai=min (lai) to get the minimum of LAI data
Maxlai=max (lai) to get the Maximum LAI data
Stdlai=std (lai) to get the standard deviation of LAI data
Avglai=mean (lai) to get the average of LAI data

Now explore the reflectance matrix and the vector of wavelengths.

Calculation of NDVI
Vegetation indices have been frequently correlated with LAI. In general vegetation indices exhibit decreasing sensitivity to LAI at increasing greenness measurements (LAI values). In this exercise Normalized difference vegetation index (NDVI), Ratio vegetation index (RVI), Difference vegetation index (DVI) as the most popular vegetation indices have been chosen.

For this exercise assume that the red and NIR bands are located at 680 nm, and 833 nm respectively (Hurcom and Harrison 1998).

☞ Open the matrix of wavelengths by double-clicking it in the workspace window and write down the corresponding index (row number) for the wavelengths 680 and 833. In this case, these wavelengths are in rows 195 and 299, respectively.

☞ In the main Menu bar on the top under the HOME click on the new script icon. A new page will be open now. Type the formula for the calculation of the indices.

These are:

- NDVI=(infrared - red)/(infrared + red);
- RVI=(infrared/ red);
- DVI=(infrared - red);

Now we want to replace the names "infrared" and "red" with the actual data.
In the reflectance matrix (also in the vector of wavelengths), the row number 195 corresponds to the red, and row number 299 corresponds to the infrared reflectance for all the 60 plots.

"samples (195,:)"	gives the red reflectance of all 60 plots as a vector.
"samples (299,:)"	gives the infrared reflectance of all 60 plots as a vector.

☞ Now rewrite the above formulas by replacing the appropriate name for infrared and red reflectance to calculate the indices.

NDVI= ….

- ❑ Note that in Matlab by writing the division like "**./**" , Matlab will calculate the division for each element in the first vector by the corresponding element in the second vector. As a result, you will have the answer as a vector.
- ❑ You can use the "**%**" sign to make the earlier formulas as comments. Therefore, they will be there as info.

Calculate the indices one by one by pushing the Run icon on the menu bar at the top of the script. A window will appear to save your script first. Give your script a name and save it in the *measured* directory.

LAI and indices relationships
In order to see how the calculated indices are related to LAI data, we will study their coefficient of determination (R^2).

To calculate the coefficient of determination between indices and LAI data use the "corrected" command and the transpose of the indices and LAI vectors.

☞E.g. In your script type:

```
r2s=corrcoef ([NDVI' lai']).^2;
```

The output is an matrix of 2*2 in which the coefficient of determination can be found at:

R2s=r2s(1,2); **or** R2s=r2s(2,1);

You can run your script step by step to evaluate the results

☞Do this for the other two indices and calculate the other two coefficients of determinations.

Which one is higher? Can you justify your results?

☞Challenge

You can use the relationship between LAI and the indices to estimate the LAI values. For this, you can use linear regression (the first-degree polynomial suffices). Your task: Calculate the RMSE of measured and estimated LAI, using the index which has a higher coefficient of determination.