Mapping from Aerial and Satellite images - Spectral lab 1

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This lab report documents the process of determining the optimal spectral band for different pixels of an image. The data processing is handled by the handout MATLAB program `cem30540.m`, which solves the constrained minimization problem of determining the optimal band, as outlined in [1]. The approach is based on the notion that the optimal band for a certain area/pixel in an image is band in which that area/pixel has the highest reflection. Ideally, the reflection of that area/pixel should be zero outside of its optimal band). As such, specific areas or groups of pixels may be classified (related to each other based on select similarities, in this case reflectance in certain bands). The described constrained minimization problem is shown in Equation 1.

$$\min\left(V\{\mathbf{w}^{\mathrm{T}}\mathbf{r}\}\right), \quad s.t. \quad \mathbf{w}^{\mathrm{T}}\mathbf{d} = 1 \tag{1}$$

Where $\mathbf{d}$ is desired spectrum, $\mathbf{r}$ contains the observations, and $\mathbf{w}$ contains the weights for the observations. A solution to the constrained minimization problem can be obtained using the classic Lagrangian multiplier technique, as shown by [1]. The technique described by [1] is implemented by the handout MATLAB program `cem30540.m`, which was run on the `avirisBand` dataset, which contains reflectance values for each of 30 bands, for an image of 360×180 pixels.

Results from `cem30540.m`

Three pixels from the `avirisBand` dataset were selected. For each of the three pixels, the optimal band computed, and the entirety of the dataset was viewed in that specific band, in an attempt at classification. The positions of the three selected pixels are shown in Table 1, and the results from `cem30540.m` for each pixel are shown in Figures Figure 1 through Figure 6.

Pixel No.	X (between 0 and 360)	Y (between 0 and 180)
Pixel 1	350	113
Pixel 2	324	75
Pixel 3	223	110

Table 1: MATLAB image coordinates of the three pixels selected from the `avirisBand` dataset.

Discussion

The results seem to depict two distinct scenarios: bands in which a non-random structure can be determined (bands 1 and 2), and a band containing indiscernible structure or noise (band 3). The structure visible in Figure 1 and Figure 3 is supported by their respective histograms (Figure 2 and Figure 4), as the variance is relatively low, and some sort of bias and/or skewness seems to be evident. The indiscernible/noisy content of band 3 seen in Figure 5 is supported by Figure 6, which shows no clear deviation from a classic Gaussian, but has a higher variance than the first two bands, making any structure in the image harder to determine (the determined band with minimal variance was not a clear indicator of anything in particular, due to the minimal variance being relatively high).

References

[1] Allan Aasbjerg Nielsen. Spectral mixture analysis: Linear and semi-parametric full and iterated partial unmixing in multi- and hyperspectral image data. *Journal of Mathematical Imaging and Vision*, 15(1-2):17–37, 2001.

Figure 1: Depiction of the `avirisBand` dataset in the optimal band of the first pixel.

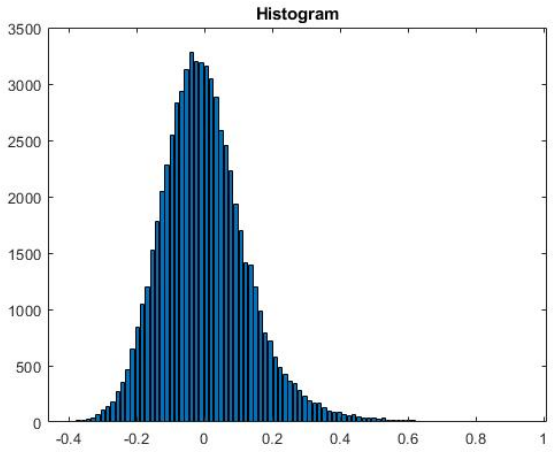

Figure 2: Histogram of the abundance of pixels in the optimal band of the first pixel. The histogram thus shows the reflectance misfit of all pixels, when described solely by the band. The histogram has a mean of -4.4505^{-16} and a variance of 0.0167

Figure 3: Depiction of the `avirisBand` dataset in the optimal band of the second pixel.

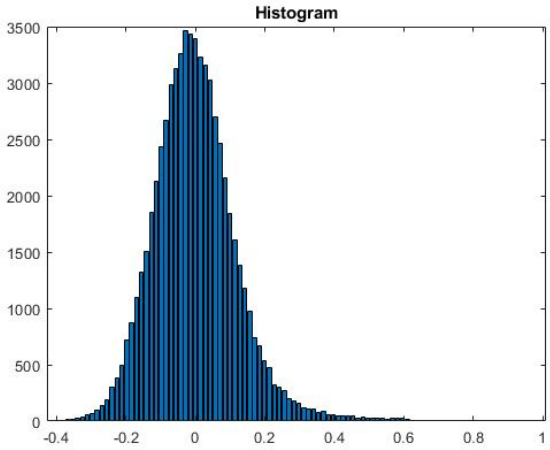

Figure 4: Histogram of the abundance of pixels in the optimal band of the second pixel. The histogram thus shows the reflectance misfit of all pixels, when described solely by the band. The histogram has a mean of 4.4245^{-16} and a variance of 0.0147

Figure 5: Depiction of the `avirisBand` dataset in the optimal band of the third pixel.

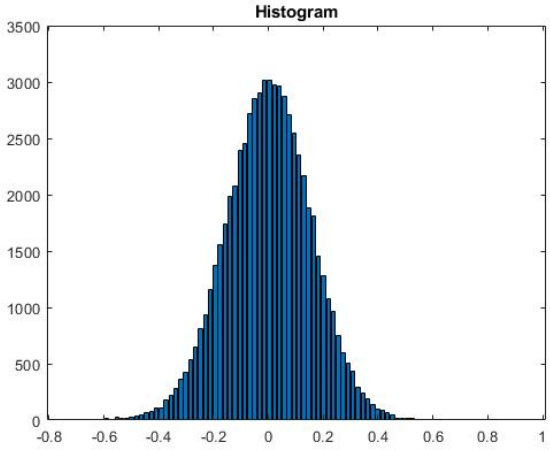

Figure 6: Histogram of the abundance of pixels in the optimal band of the third pixel. The histogram thus shows the reflectance misfit of all pixels, when described solely by the band. The histogram has a mean of -3.6634^{-16} and a variance of 0.0243