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Kucheryavskiy, Sergey

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A novel method for discrimination of objects on hyperspectral images

Sergey Kucheryavskiy, Aalborg University, Denmark

1. Introduction

Discrimination of objects on hyperspectral images is one of the most common problems has to be solved in various applications, e.g. detection of spoiled fruits or cereals, defective or counterfeit pills, counting objects with particular properties or chemical composition and so on.

The solution is pretty straightforward: segment objects, calculate their features, and apply discrimination or classification algorithm using the features as predictors. Feature extracting is the most challenging part here. For conventional RGB imaging there is a wide range of methods already developed, allowing, for example, to describe quantitatively statistics of color distribution, textural and shape properties or their combinations. However for hyperspectral images they are often not applicable.

The aim of this work was to create a simple and efficient method for extracting features of objects on hyperspectral images to be used for discrimination and classification purposes.

2. Case study

To introduce the key points of the proposed method as well as to show its performance, comparing to well known average spectra approach, hyperspectral images of 52 calcium pills were used. There were two types of pills — 26 with 400 mg of calcium carbonate and 19 μg of cholecalciferol (vitamin D3) and 26 with 400 mg of calcium carbonate, 10 μg of cholecalciferol plus 150 mg of magnesium.

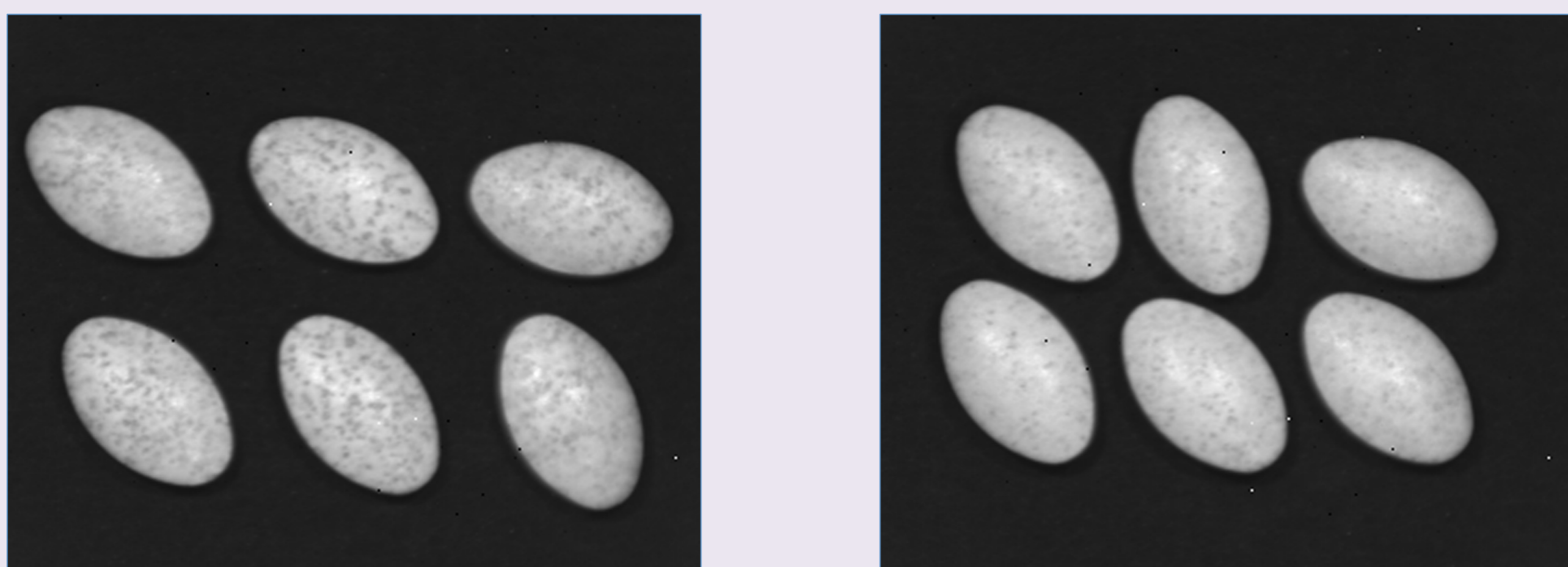


Fig. 1. Calcium pills

The hyperspectral images were acquired using Spectral Dimensions MatrixNIR chemical imaging system with a spectral range 960–1662 nm, spectral resolution 6 nm and spatial resolution 320x256 pixels. Fig. 1 shows grayscale images of some pills for 1440 nm band. The score density plot did not show any clusters, so the discrimination problem had to be solved object wise — by calculating features for every object.

3. The method

The main idea of the proposed method is to build a joint principal component space for all objects' pixels and then, for every object, detect a pattern, pixels from this object share in the space. Here, pattern means shape and density of spatial distribution of the pixels.

Figure 2 illustrates these ideas. In all plots (also later in Figure 3) red and blue colors correspond to different types of pills (classes). Left plots in Fig. 2 were made for original spectra, right — for SNV corrected spectra.

The top of the figure shows score plots for the pixels of all pills. Obviously, pixels from different types of pills tend to form different patterns in the PC space. To estimate the patterns quantitatively we propose to use histogram of score values distribution. Thus, for every object the histograms were calculated for each principal component and concatenated into a feature vector as it is shown in the bottom of Fig. 2 (4 PCs, 20 bins).

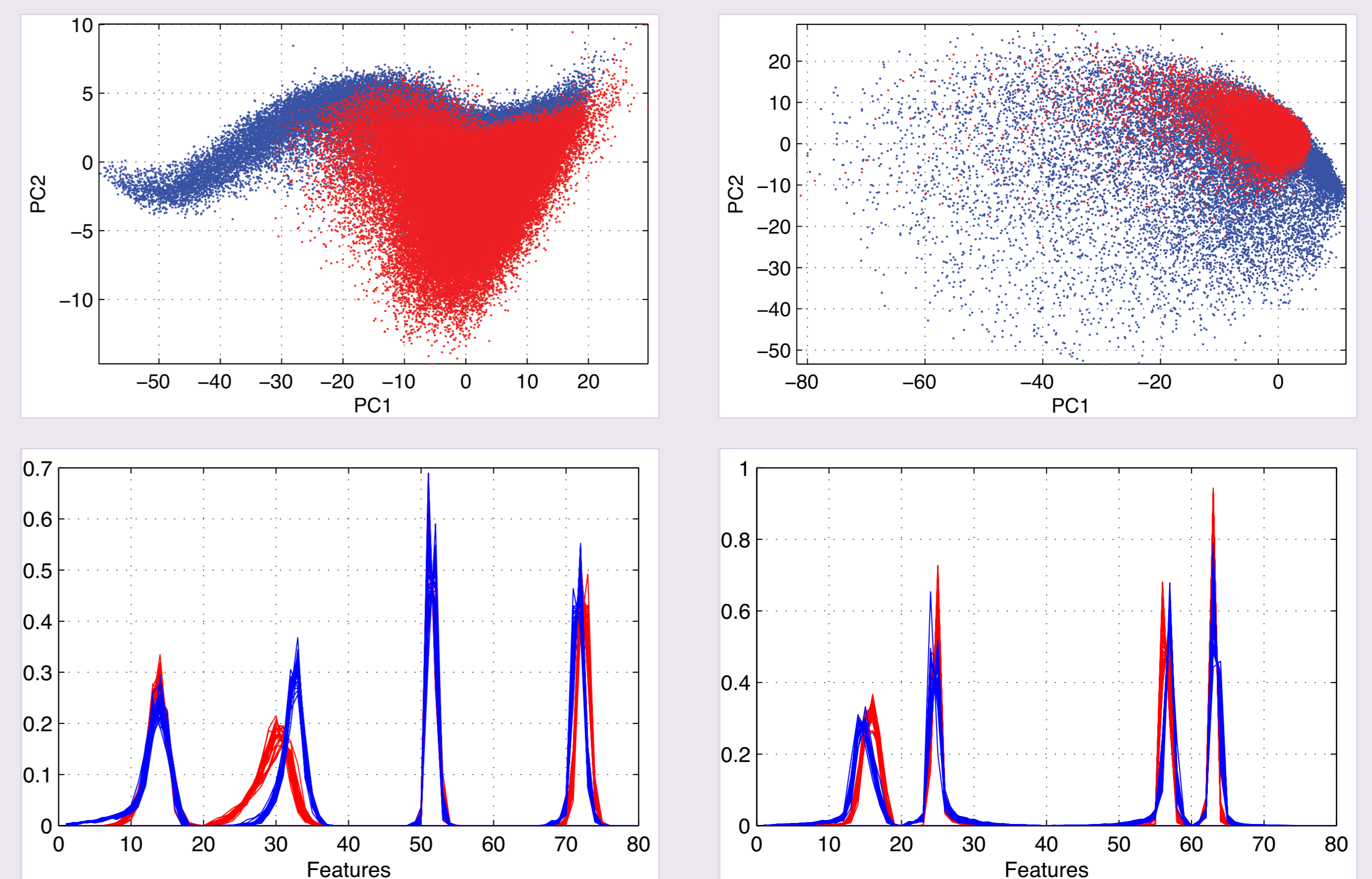


Fig. 2. Scores plots for pixels and concatenated histograms for objects

4. Discrimination results and comparison

The method was compared with average spectra approach, where mean spectrum of every object is used as the object's feature vector. The comparison was done for two cases — for all bands and for only problematic part of spectra, where the objects are hardly distinguishable. The results of modeling and comparison are shown in Fig. 3 (all spectra were SNV corrected).

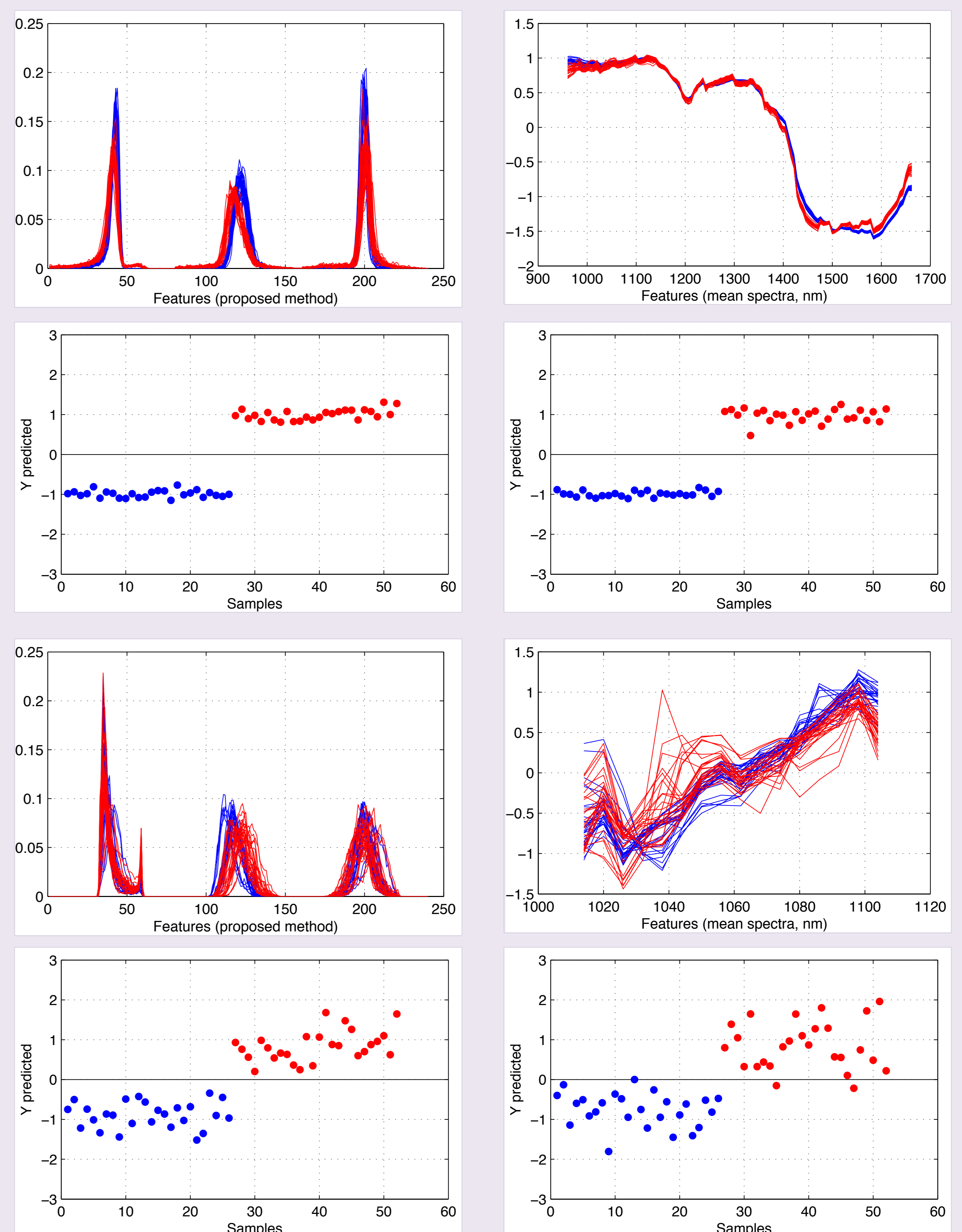


Fig. 3. Features and PLS-DA results for proposed method and averaged spectra

It can be seen that both methods worked well when the whole spectral range is used, but for the challenging part the proposed method performed better giving a model with no misclassified objects. We believe the method can be particularly useful for the cases, where objects from different classes have many chemically similar pixels, and open for any collaboration.

