HyRANK: THE NEW ISPRS HYPERSPECTRAL BENCHMARK

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ABSTRACT:

The main objective of the new ISPRS hyperspectral dataset and benchmark, named HyRANK, was to fill the current gap regarding the limited availability of hyperspectral datasets and benchmarking frameworks for validating new classification methods against the state-of-the-art. In order to do so, we have collected a set of hyperspectral datasets and manually annotated them. The emphasis was on datasets with a relative large size and several land cover classes. In particular, fourteen land cover classes were annotated and an adequate set for both training and testing was formed. Users can download the hyperspectral datasets along with the corresponding reference/ labelled data and apply offline their training and prediction frameworks. Then, they can upload the resulting classification map, at a predefined format and the online-calculated overall accuracy is reported on benchmark's website. The back end of the platform consists of an Apache web server responsible for the delivery of a Django (python) application powered by a PostgreSQL database. The python application is responsible for serving the results and for the evaluation of the submitted predictions/ maps. The benchmark platform can be reached through the ISPRS website under the Commission III, Working Group III/4 'Hyperspectral Image Processing' webpage.

1. INTRODUCTION

During the last decade the majority (Xu and Shi, 2017; Gu et al., 2017; Yokoya et al., 2017; Ghamisi et al., 2017; Chang, 2018) of the developed classification algorithms have been validated by assessing their performance on just a few openly available hyperspectral remote sensing datasets like Indian Pines, Salinas, Pavia and Cuprite[1].

However, these datasets are relative small in size (e.g. few hundred pixels by few hundred) and usually the annotated samples are referring to a small number of terrain classes (i.e., around ten. For example, the Indian Pine dataset which has sixteen classes has a size of 145 by 145 pixels and the Pavia University has nine classes and a size of 610 by 340 pixels.

With a relative small image size and a relative small number of classes, the available annotated samples (which do not cover all image pixels) must be further divided into training and testing sets in order to validate the performance of any classification framework and its sensitivity to arbitrary selected pixels/ training and testing sets. The few pixels that are remaining for validation and the fact that the training has been performed on the same image and therefore adjacent pixels are both used for training and validation, largely can explain the current high scores in overall accuracy rates that modern algorithms achieve (Makantasis et al., 2015; Gu et al., 2017; Ghamisi et al., 2017).

Towards addressing the aforementioned limitations, in this paper, we introduce a new Benchmark for Hyperspectral Image Processing, named HyRANK, which was developed in the framework of ISPRS Scientific Initiatives, ISPRS Commission III, Working Group III/4 'Hyperspectral Image Processing'. In particular, the goal was to tackle current challenges of openly available hyperspectral datasets like, image size, relative small size of training and validation sets, limited number of annotated land cover classes.

2. THE SATELLITE HYPERSPECTRAL DATASET

Currently, HyRANK has made openly available a satellite hyperspectral dataset along with the corresponding reference/ ground truth data for assessing the performance of different algorithms on land cover mapping. The satellite hyperspectral data have been obtained from the Hyperion sensor, carried by the National Aeronautics and Space Administration (NASA) Earth Observing 1 (EO-1) satellite. Hyperion was the first spaceborne hyperspectral instrument to acquire both visible near-infrared (VNIR, 400-1000nm) and shortwave infrared (SWIR, 900-2500nm) spectra. Five Hyperion surface reflectance datasets were acquired from the EarthExplorer platform of USGS (Table 1). All images were acquired during 2006 between late May and early July in the same geographical area.

The Five Hyperion Images of HyRANK

id	Name	Image Size	Spectral Bands	Spatial Resolution	Training/ Validation
1	**Dioni**	250 x 1376 x 176	176	30m	*training*
2	**Loukia**	249 x 945 x 176	176	30m	*training*
3	**Erato**	241 x 1632 x 176	176	30m	*validation*
4	**Nefeli**	249 x 772 x 176	176	30m	*validation*
5	**Kirki**	245 x 1626 x 176	176	30m	*validation*

Table 1. The five Hyperion hyperspectral images of HyRANK for land cover mapping.

The Hyperion VNIR sensor delivers 70 spectral bands and the SWIR 172 bands, providing 242 potential bands. Similar to several studies (Datt et al., 2003) a significant number bands were removed from the hypercube due to the fact that certain of them were intentionally not illuminated, others correspond to areas of low sensitivity or to the overlap between the two spectrometers or they have relative high SNR and correspond to atmospheric water vapour absorption bands. Therefore, after the band removal process a total of 176 bands (Datt et al., 2003) were derived and formed each hypercube.

2.1 Annotated data and Land Cover classes

One main difference comparing with the current standard datasets of HyRANk is that the annotated data contain several land cover/use classes. In particular, the nomenclature employed here was derived mainly from CORINE Land Cover (CLC) and contained 14 classes. These classes are appearing in the two images that form the training set (i.e., Dioni and Loukia) as well as the three images that form the validation set (i.e., Erato, Nefeli and Kirki).

An intensive manual annotation procedure was carried out for the production of reference data. Two image interpretation experts manually digitized polygons for the different land cover classes using a variety of datasets including the Hyperion images (2006), the Corine Land Cover Map (CLC2006), Google Earth data, very high resolution data (e.g., IKONOS, QUICKBIRD of 2006) and open geospatial data regarding the forest types and crop fields. Examples of the annotated in the Hyperion data polygons with the 14 land cover classes are shown in Figure 1, overlaid on high resolution data.

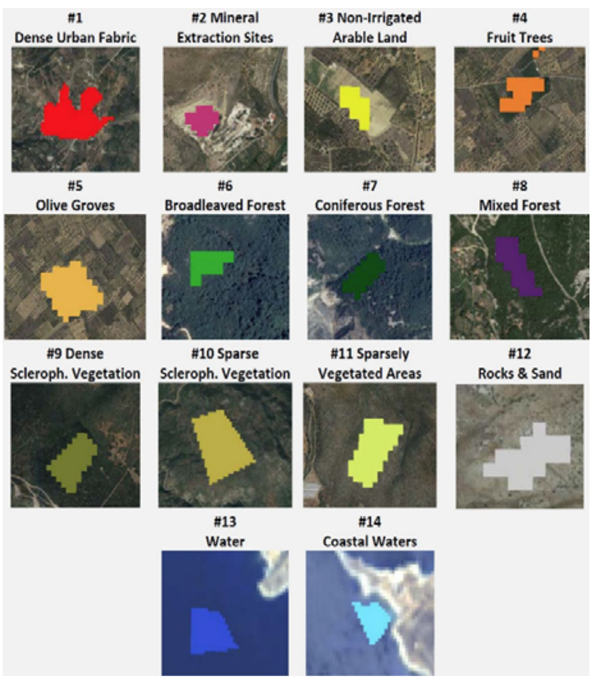

Figure 1. The annotated hyperspectral data contain 14 different land cover classes based mainly on Corine Land Cover nomenclature focusing on the land cover terrain classes.

2.2 Training and Validation Datasets

The training set contains two hyperspectral images (i.e., Dioni and Loukia). Fourteen land cover classes (Figure 1) have been carefully annotated taking into account both the hyperspectral data as well as high and very high resolution data of the same year. In Figure 3, a colour composite (R:23,G:11,B:07) from the Loukia (top) and Dioni (bottom) images are presented along with the annotated training set.

The validation set contains three hyperspectral images (i.e., Erato, Nefeli, Kiriki). Fourteen land cover classes (Figure 1) have been carefully annotated taking into account both the hyperspectral data as well as high and very high resolution data of the same year. The validation set won't be openly available to the community and it will be used for the automated evaluation and accuracy metrics calculation in the HyRANK platform. In Figure 4, a colour composite (R:23,G:11,B:07) for the Erato (top), Nefeli (middle) and Kiriki (bottom) images are presented.

3. THE HyRANK BENCHAMRK PROCEDURE

Users can download the hyperspectral datasets[1] along with the corresponding reference/ labelled data (Karantzalos et al., 2018) and apply offline their training and prediction frameworks. Then, they can upload the resulting classification map, at a predefined format and the online-calculated overall accuracy is reported on benchmark's website. The back end of the platform consists of an Apache web server responsible for the delivery of a Django (python) application powered by a PostgreSQL database (Figure 2).

The python application is responsible for serving the results and for the evaluation of the submitted predictions/ maps based on the annotated datasets of the validation set (Figure 2).

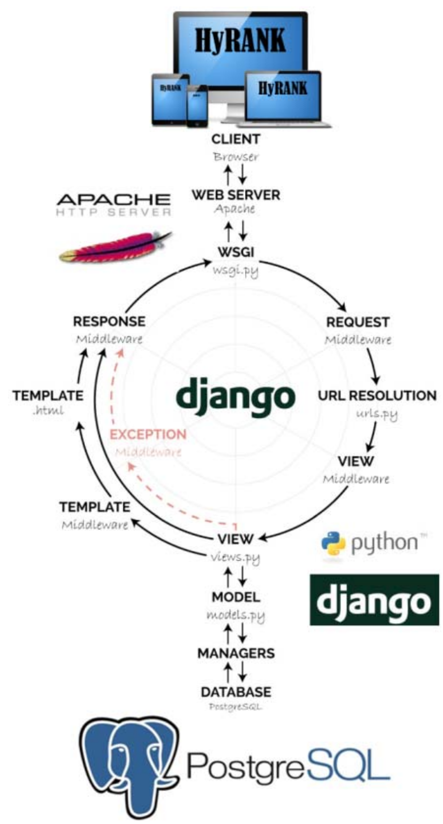

Figure 2. The back end of the HyRANK platform integrates different open source tools including an Apache web server, Django (python) applications and a PostgreSQL database.

[1] http://doi.org/10.5281/zenodo.1222202

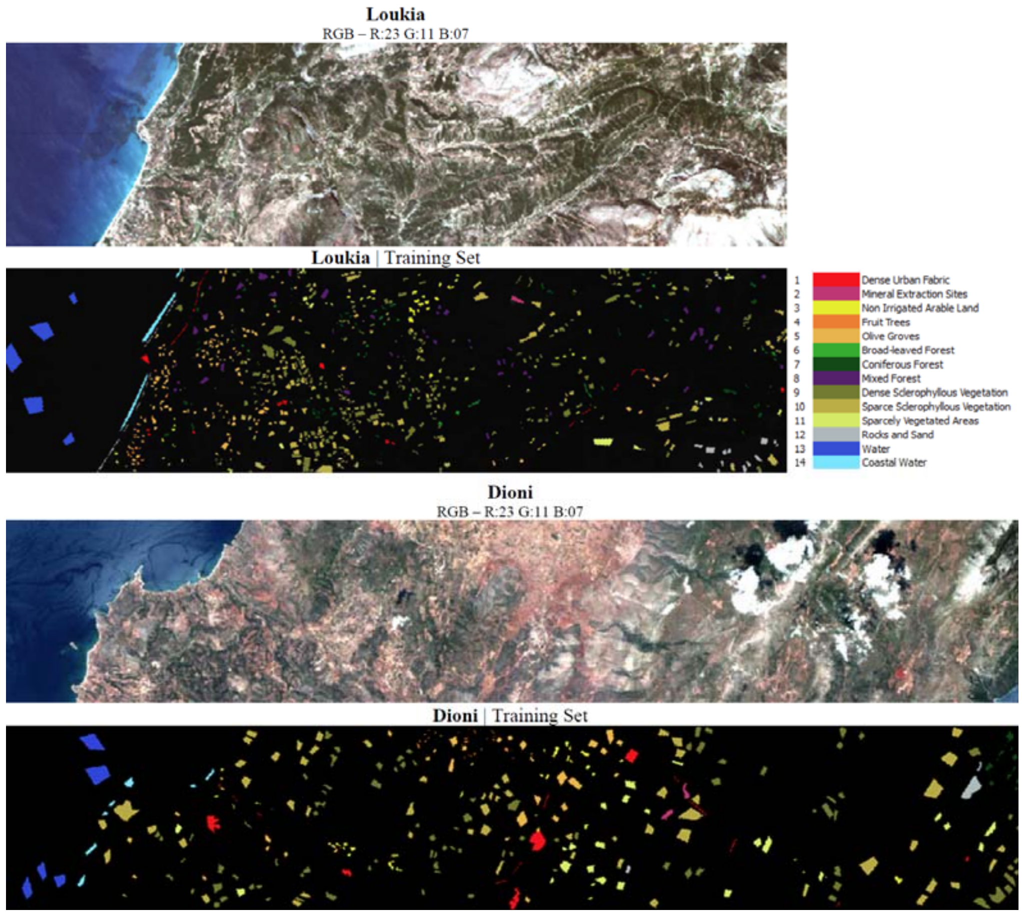

Figure 3. For the training set contains two hyperspectral images (i.e., Loukia and Dioni) have been carefully annotated with the 14 land cover classes.

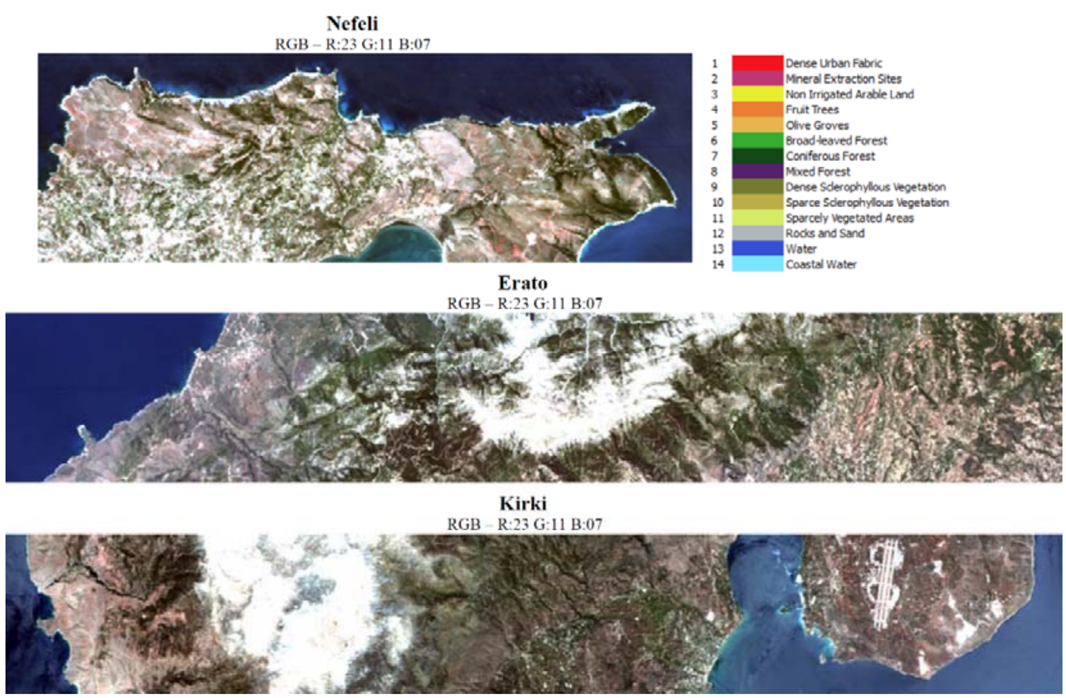

Figure 4. The validation dataset contains three hyperspectral images (i.e., Nefeli, Erato and Kirki). The annotated samples contain all 14 land cover classes.

The benchmark platform is available through the ISPRS website under the Commission III, Working Group III/4 'Hyperspectral Image Processing' webpage. Both training and validation datasets have been selected in order to contain almost all considered land cover classes and represent different geographical regions, altitudes and terrain complexity. Moreover, the acquired dates did not differ significantly ensuring similar phenological characteristic for e.g., the vegetation classes.

Comparing with similar benchmark initiatives like the HyperLabelMe (Munoz-Mari et al., 2017), HyRANK offers directly training and validation images and therefore all type of algorithms including the ones that are based on spatial relationships can be applied and evaluated.

4. CONCLUSIONS

HyRANK is a new hyperspectral benchmark platform and dataset which was developed in the framework of ISPRS Scientific Initiatives. Users can download the hyperspectral datasets along with the corresponding reference/ labelled data and apply offline their training and prediction frameworks. Then, they can upload the resulting classification map, at a predefined format and the online-calculated overall accuracy is reported on benchmark's website. The back end of the platform consists of an Apache web server responsible for the delivery of a Django (python) application powered by a PostgreSQL database. The python application is responsible for serving the results and for the evaluation of the submitted predictions/ maps. The benchmark platform is available through the ISPRS website under the Commission III, Working Group III/4 'Hyperspectral Image Processing' webpage.

Currently, the HyRANK benchmark contains data from satellite hyperspectral datasets. Among the future perspectives, one is to include imaging and annotation data from aerial (manned and unmanned) vehicles as well as other e.g., terrestrial acquisition platforms with both hyperspectral images and video sequences. In this context, all suggestions and contributions are welcomed towards providing decent, challenging benchmark datasets to the scientific community.

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