Hyperspectral Imaging for Analysis and Classification of Plastic Waste

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Abstract

Environmental protection is one of the main challenges facing society nowadays. Even with constantly growing awareness, not all of the sorting can be done by people themselves - the differences between materials are not visible to the human eye. For that reason, we present the use of a hyperspectral camera as a capture device, which allows us to obtain the full spectrum of the material. In this work, we propose a method for efficient recognition of the substance of an item. We conducted several experiments and analysis of the spectra of different materials in different conditions on a special measuring stand. That enabled the identification of the best features, which can later be used during classification, which was confirmed during the extensive testing procedure.

Problem

The problem is to classify the different materials that are impossible to classify with RGB color camera. For example it is beneficial to distinguish PET (PolyEthylene Terephthalate) bottle from HDPE (High Density PolyEthylene) cap or PP (PolyPropylene).

Fig. 1: Visualization of the captured data in one of the camera and and in RGB palette

Method

Fig. 2: Measuring stand equipped with camera and lighting

Our measurements were made using a hyperspectral camera: *Specim FX17*, which can collect data from NIR & SWIR range $(900 - 1700nm)$ and common white halogen lamp as a light source.
During research on the classifiers we examined several of them, but from the beginning their selection was limited to only those ones that can result in a low execution time. That included decision trees, random forest, extra trees classifier and LightGBM.
We verified which bands are most often selected for classifiers of all pairs of materials and performed the experiments with limited bands.

Results

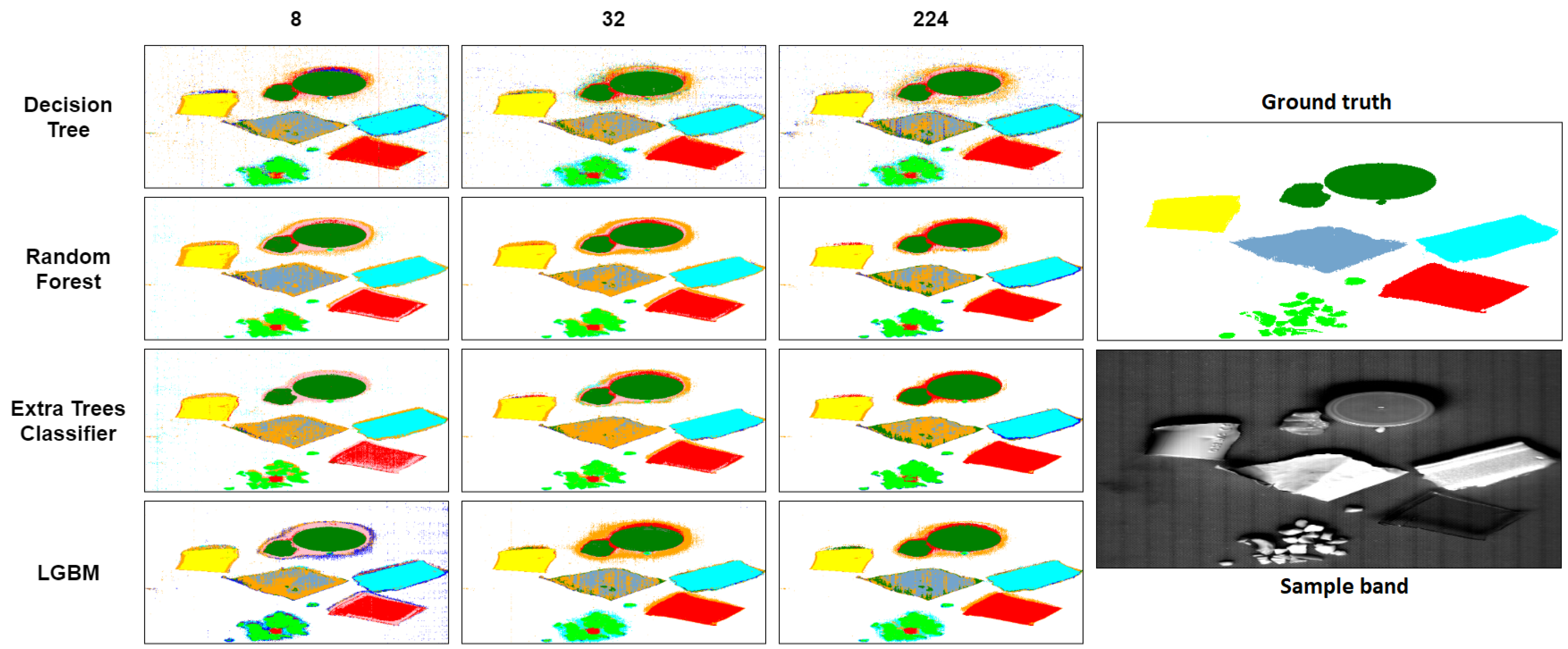

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Fig. 3: An example of the classification result of test data

In the image there are results using different classifiers with mean normalization using different numbers of bands selected as an input features. It is shown that different materials have different reflectance spectra. Some of the bands (eg. around $1650nm$) are more diverse than others.

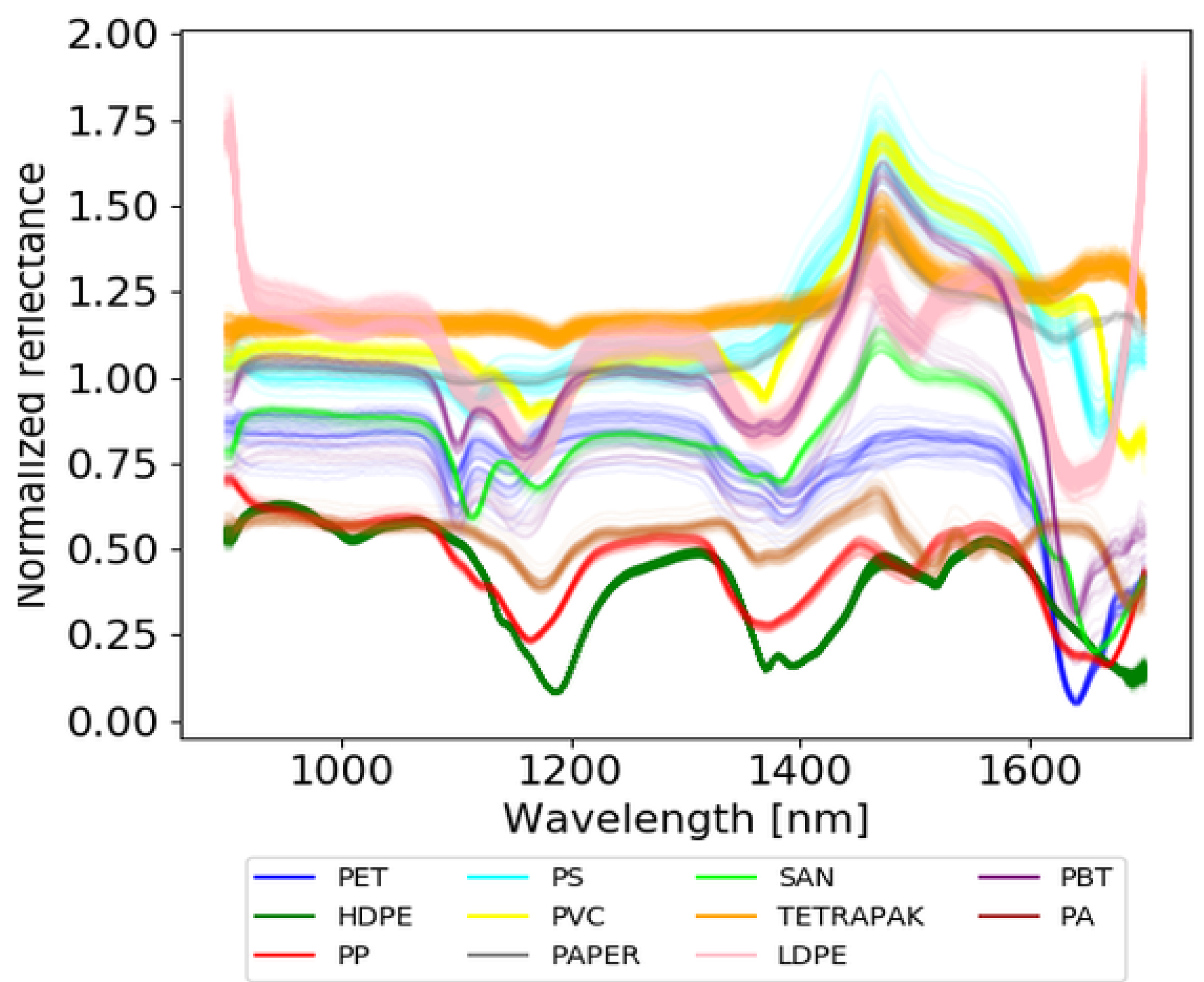

Fig. 4: Reflectance of materials samples

Conclusion

Classification results prove that NIR & SWIR spectrum can be successfully used to create a waste-sorting system. Thanks to identification of important bands and their limitation, it was possible to achieve a real-time solution. The thickness of the materials (either parts of the objects or the caps) did not influence the results.
Sorting transparent materials caused several problems because of the conveyor belt, but in the real system the mechanical solution can be different; identification can be done during the flight of the object. For future work, we propose the combination of the NIR & SWIR system with an RGB camera to support identification of those materials that are difficult to recognise and which cannot be captured with the NIR & SWIR hyperspectral camera.

Acknowledgements

The project (RPMA.01.02.00-14-a162/18) was co-financed from the European Regional Development Fund under the Regional Operational Program of the Mazowieckie Voivodeship 2014-2020.