Application Note

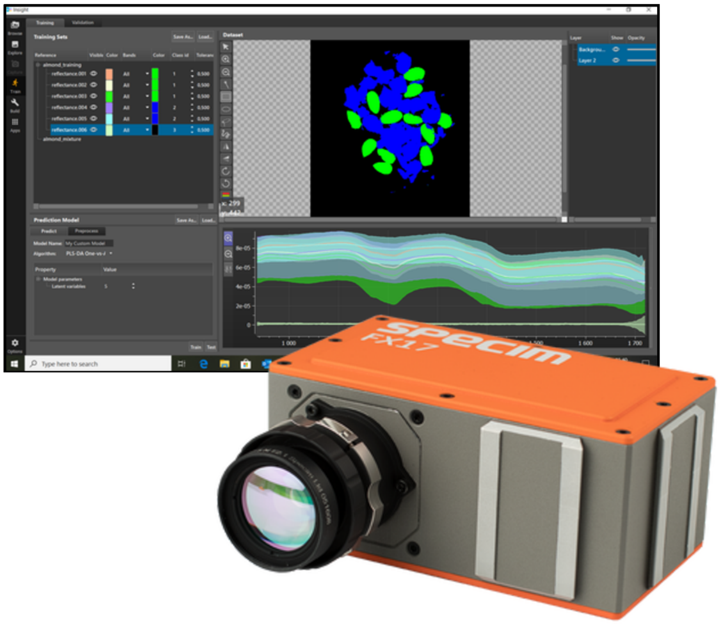
Classification of White Plastics using Specim FX17 and INSIGHT

Revolutionizing Plastics Identification and Sorting with Hyperspectral Imaging

In applications such as plastics sorting and recycling, it is important to be able to quickly and accurately identify one type of plastic from another. Attempting to do this manually is both time-consuming and prone to error.

Hyperspectral technology can identify different materials accurately and reliably based on their chemical composition. By measuring and analyzing the spectrum of light reflected from the material, different types of plastics can be identified. Hyperspectral imaging technology is particularly useful when trying to identify plastics that appear the same color.

By combining hyperspectral cameras and image processing software, models can be created which can distinguish one type of plastic from another based on their spectral signature. These models can then be deployed into industrial applications to automate the process of plastics sorting in a way that is faster and more accurate than alternative methods.



This application note will focus on using the Specim FX17e NIR hyperspectral camera and SpecimINSIGHT software to accurately identify and classify different types of white plastics.

Experimental Setup

Equipment

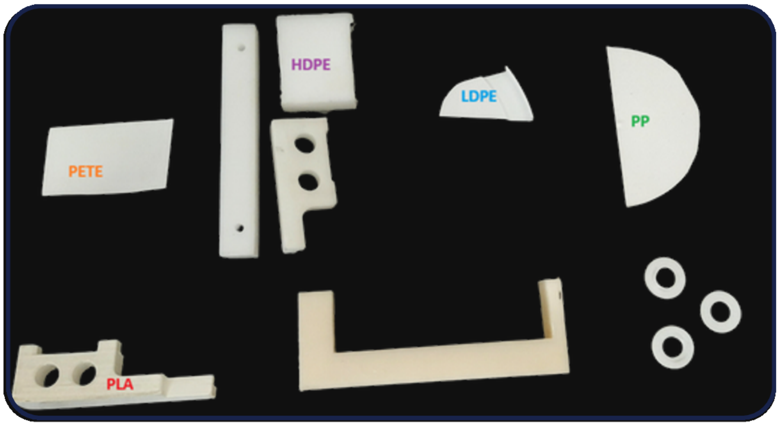
- Specim FX17e NIR Hyperspectral Camera with 38° FOV lens and GigE Interface
- Specim 40x20 LabScanner
- SpecimINSIGHT data analysis software.

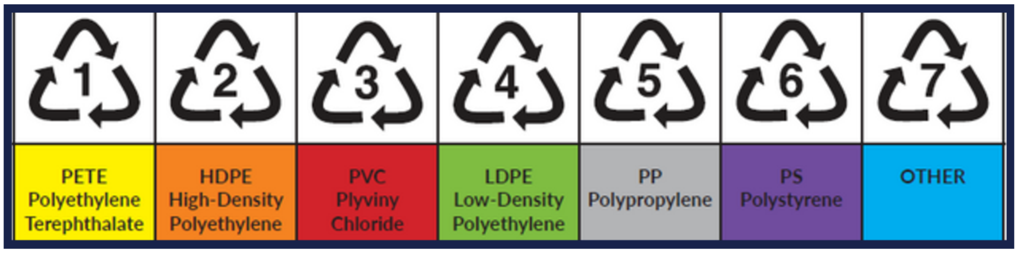
The Specim FX17e camera was mounted to a Specim benchtop LabScanner equipped with dual halogen illumination and a 40cm x 20cm sample tray. LUMO Scanner software developed by Specim was used to synchronize data acquisition of the camera with the movement of the scanning table, ensuring hyperspectral measurements of the samples would be properly collected in the correct aspect ratio.

Types of Plastics Imaged

The following types of plastics were imaged:

- Polyethylene Terephthalate (#1 PETE)
- High Density Polyethylene *#2 HDPE)
- Low Density Polyethylene (#4 LDPE)
- Polypropylene (#5 PP)
- Polylactic Acid (PLA)
- Teflon
- Nylon

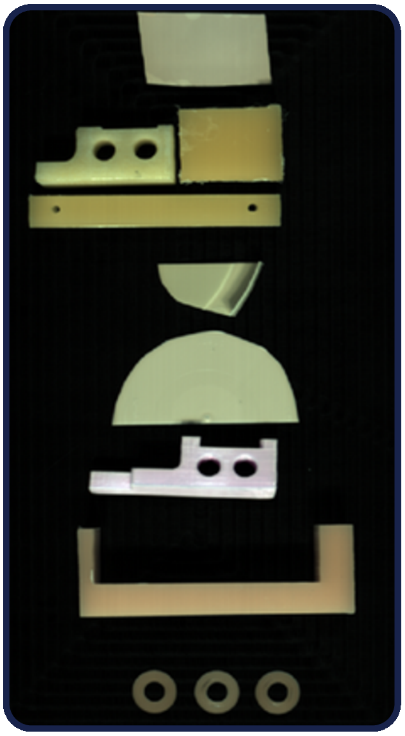


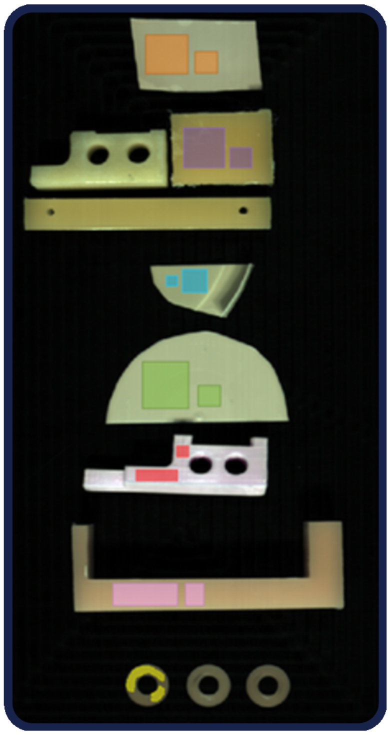


Data Collection

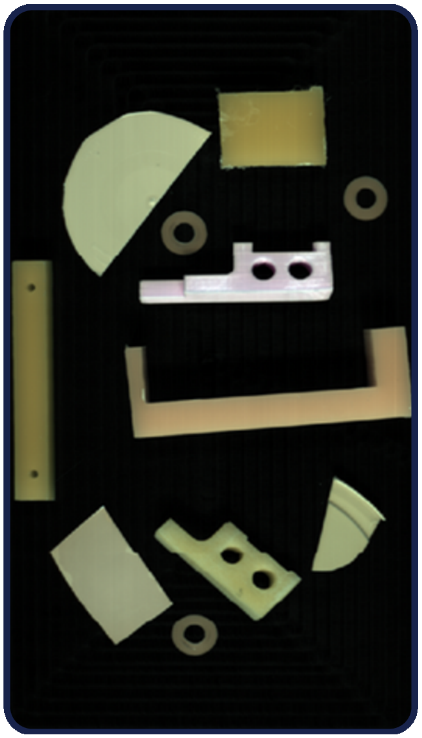
Two sets of measurements were collected with the FX17e; one for training and validation used to create the model in SpecimINSIGHT, and one Inspection Dataset to test the model for accuracy and classify the samples.

Training & Validation Dataset





Inspection Dataset



Once both datasets were collected, they were uploaded into SpecimINSIGHT. Two sets of selections were made for each plastic sample from the Training & Validation Dataset, as seen above; one larger selection used to train the model, and one smaller selection used for validation.

Each selection was classified as the associated plastic type and assigned a color for visible differentiation in the final inspection output.

Two pre-processors were applied to the model to improve accuracy and robustness; the Savitzky-Golay filter, which smooths out the spectra to eliminate noise, and the Standard Normal Variate scaler, which scales the data to be compared more accurately.

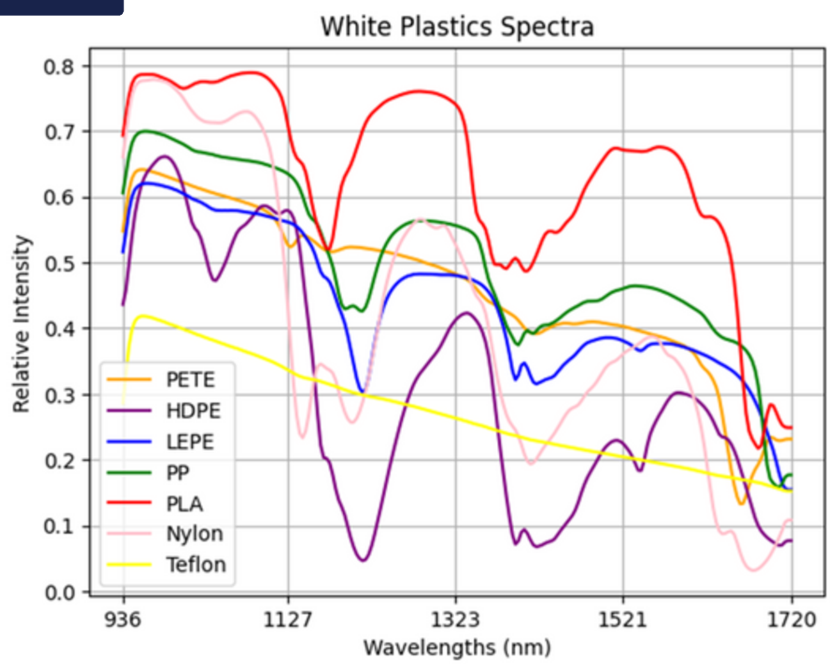
SpecimINSIGHT Model Generation & Validation

Training Selection Mean Spectra

The mean spectra for each of the training selections were plotted.

Spectral similarities between some of the samples were observed, though enough differences exist to easily differentiate all of the plastic samples from each other based on their spectra.

This indicates that a model trained from this data would be successful at identifying one type of plastic from the other within this sample set.



Model Performance Analysis

The below table, produced when a model is created in SpecimINSIGHT, demonstrates how well the model performed at indentifying the validation data.

Expected	PETE	HDPE	LDPE	PP	PLA	Nylon	Teflon	Unclassified	Background	Precision (%)
Predicted										
PETE	1122	0	0	0	0	0	0	0	0	100.00
HDPE	0	1023	0	0	0	0	0	0	0	100.00
LDPE	0	0	288	0	0	0	0	0	0	100.00
PP	0	0	0	1122	0	0	0	0	0	100.00
PLA	0	0	0	0	324	0	0	0	0	100.00
Nylon	0	0	0	0	0	986	0	0	0	100.00
Teflon	0	0	0	0	0	0	282	0	0	100.00
Unclassified	0	0	0	0	0	0	0	0	0	-
Background	0	0	0	0	0	0	0	0	0	-
Recall (%)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	-	-	

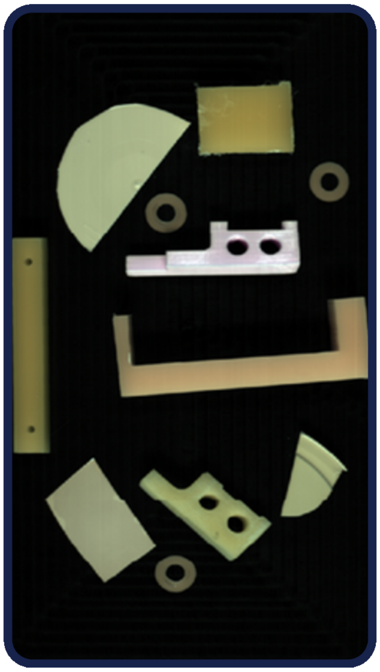
The results from this table indicate that the model performed exceptionally well with all precision and recall scores being 100%. Based on this, it would be expected that the model would be very successful when applied to real world applications.

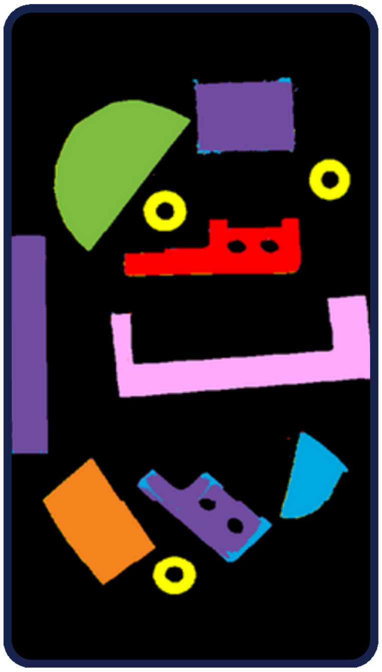
Results

Inspection Dataset Evaluation

The model created using the training and validation dataset was applied to the Inspection Dataset in SpecimINSIGHT.

The classified inspection dataset demonstrates the effectiveness of the model, outputting only a few misclassifications on the edges of a select few samples.





Conclusion

The FX17 hyperspectral camera operates in the 900nm to 1700nm wavelength range, which is the range that contains prominent spectral features from the different plastic samples included in this analysis. Not all types of plastic will give sufficient reflectance for modelling in this range, and it is advised to research which cameras will work best for a given type of plastic.

SpecimINSIGHT was very useful in working with the datasets collected by LUMO Scanner. Not only were we able to produce models that accurately classified the different types of plastics, but it also provided tools for exploring the data. Being able to explore the datasets and identify how the different spectras appear allows the user to adjust the training parameters to create more successful models.

While Insight can perform inspection by running the model on additional datasets, the model can also be deployed onto a device such as the SpecimCUBE which will allow hyperspectral cameras to be integrated into an assembly line, allowing for real time classification of white plastics.