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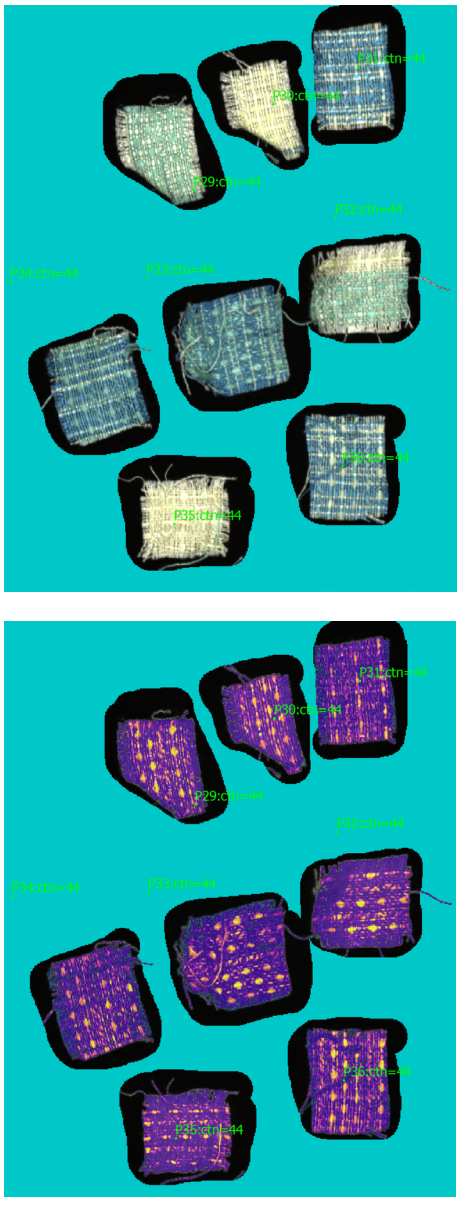
Headwall APPLICATION NOTE

Sorting Textiles for Recycling

Using the MV.C NIR and the perClass Mira Stage and Software



Above: a false RGB colorization of a NIR hyperspectral image of swatches of a linen/cotton blend. Below: a regression heat map showing regions of high (yellow) and low (purple) concentrations of cotton threads.

Of the many efforts of conservation and reduction of waste, textiles remain one of the greatest challenges. The United States EPA estimates that of the 25 billion pounds of post-consumer textile waste recycled, only 15% is recycled and repurposed, while the remaining 85% of it ends up in landfills.[1] The challenge facing textile recycling projects is discerning between similar looking fabrics at a high throughput.

Traditional sorting methods (such as an air classifier) are prone to errors with fabrics that have similar densities and air resistances. Chemical sorting offers high accuracy, but requires destruction of the current materials, and is unavailable for some fabrics (such as wool).[2]

Other sensors that rely on RGB or multispectral imaging only offer a glimpse into the spectral nature of the different

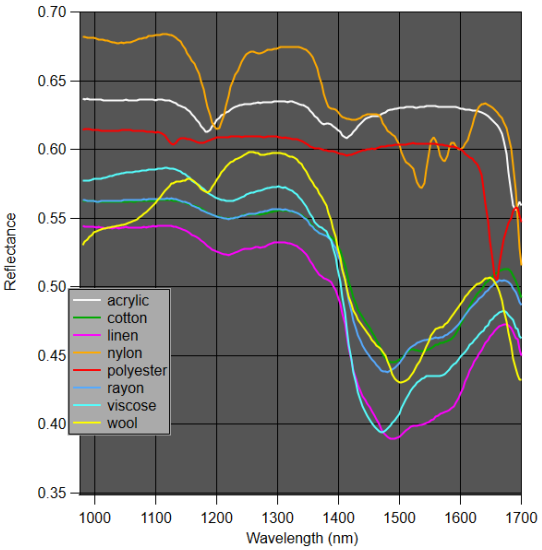
fabrics, and fail to adequately sort through fabrics of different textures. The ideal solution for this challenge would be a non-contact classifier that can sort the different fabrics and blends at high speeds. With **Headwall**'s hyperspectral imaging (HSI) sensors, and **perClass Mira**'s machine learning software, Headwall provides a potential solution to this problem.

EXPERIMENT OVERVIEW

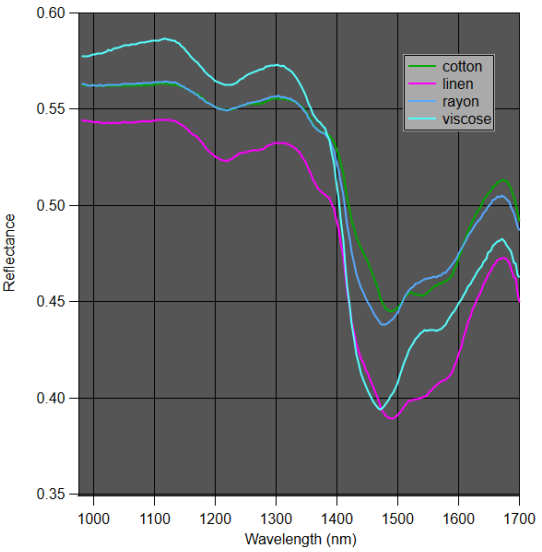
Pieces of fabric with different colors were provided, each with varying percentages of cotton, wool, or synthetic blends. The swatches of fabric were scanned on a perClass Mira stage with Headwall's **MV.C NIR** sensor, and the hyperspectral data processed with perClass Mira Software. The pure fabric varieties included:

- acrylic
- cotton
- linen
- nylon
- polyester
- viscose
- wool.

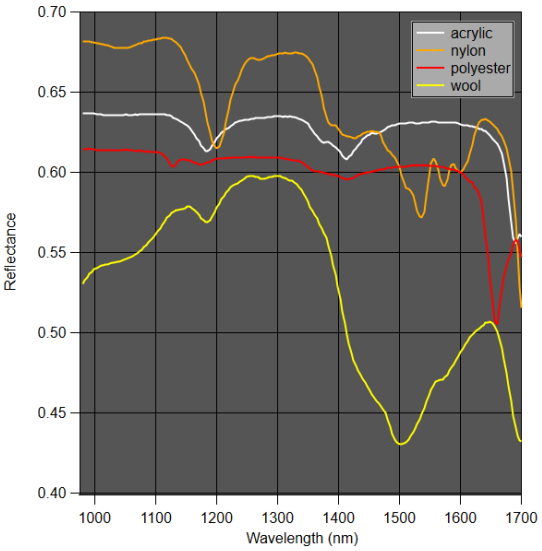
A spectral library of pure fabrics was gathered, and a classification model was built. In addition, swatches of fabric with different percentages of material were scanned and a regression model was built to estimate the percent composition of unknown swatches.

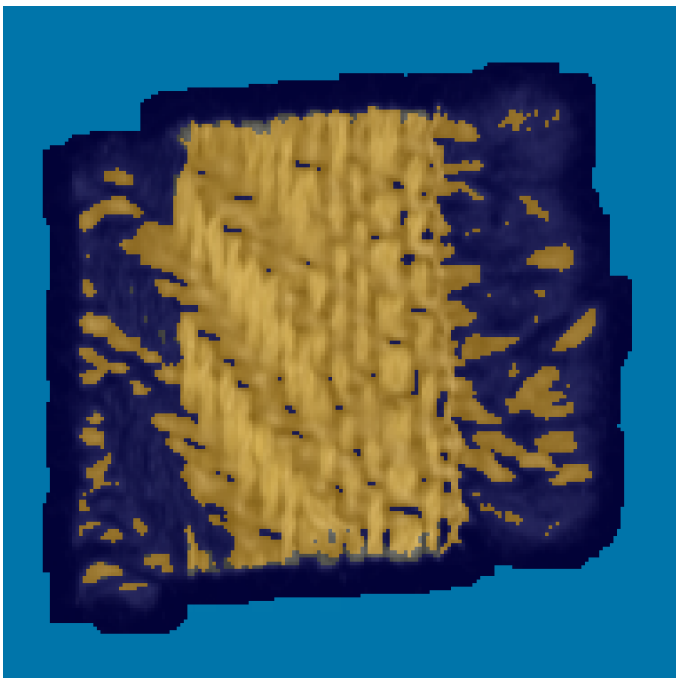


The mean spectra of various fabrics over the NIR region. Some of the natural fabrics, such as cotton and rayon, have almost identical spectra.

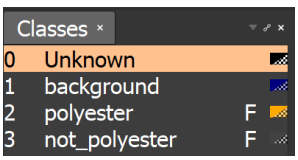


The mean spectra of fabrics that have similar spectral patterns to cotton in the NIR region.





The first image is a false-RGB coloring of a NIR scan of a swatch of fabric that is 95% polyester and 5% wool. The second image is the per-pixel classification of the image, illustrating that the classification model is able to distinguish between regions in the fabric that contain polyester and the regions that contain wool.



CLASSIFICATION MODEL

Many fabric varieties have similar chemical and physical properties, which is why mechanical sorters and imagers struggle to differentiate between them. This can be also be seen in the spectral patterns of the different fabrics collected in the Near Infrared Range (900 nm to 1700 nm).

To work around this, a binary classification model was made for different fabrics, to determine whether the swatch contained a particular material. In the classification model shown at the top of the opposite page, three classes were created: background, polyester fabric, and non-polyester. The classification model was trained solely on pure fabric swatches, and tested against the blended swatches. The model was 100% accurate when sorting with a 5% pixel threshold, and 98% accurate when sorting with a 1% pixel threshold. With this rate of success, a tailored model can offer better performance by sorting for a specific type of fabric, and using a multiple stage sorting option.

REGRESSION MODEL

Since most clothing items are blends of multiple fabric varieties, the ideal sorting solution would include a way of estimating the fabric composition. A regression model was built using swatches of different percentage blends of cotton. The samples varied in blend, concentration, and color.

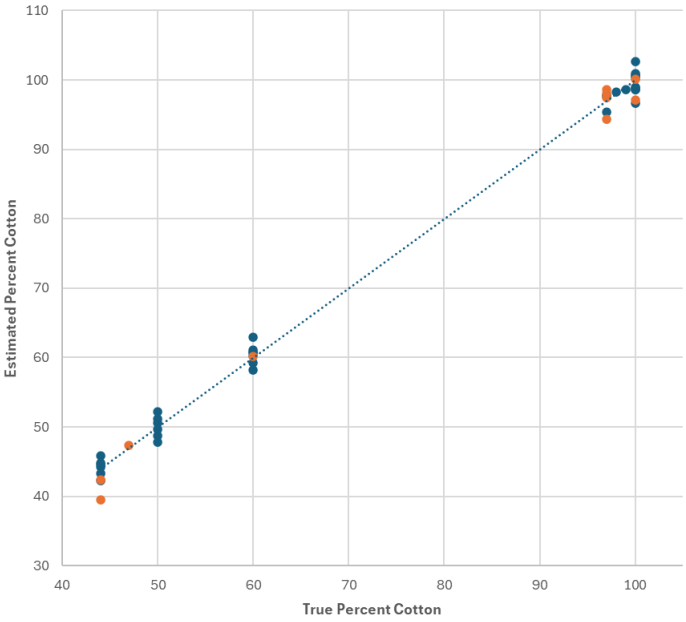
The training set showed strong correlation, and utilizing the regression visualization tools in perClass Mira, the different fabric strands were more visible than to the naked eye.

SUMMARY AND DEPLOYMENT

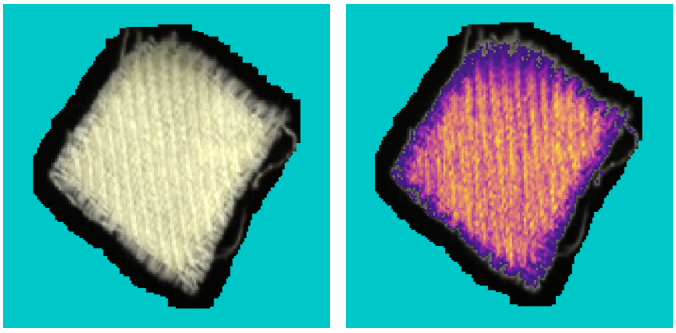
Many fabrics have distinct spectral signatures in the NIR spectral range, and hyperspectral imaging and classification model can be paired together to recognize these fabrics. Specialized binary models offer a path to a multi-stage approach to sort similar, pure fabrics. For blends of fabrics, hyperspectral imaging offers a way to estimate the percent composition. Headwall's MV.C NIR paired with perClass Mira's machine learning software offers a non-contact, real-time sensor for sorting and repurposing our recycled fabrics.

WANT TO KNOW MORE?

Our Headwall Applications Team will work with you to explore how HSI can deliver value to your fabric processing facility. **Contact us to learn more!**



Training (blue) and test (orange) data for the model created to estimate the percent cotton in a blend of fabric.



The left image is a false-RGB coloring of a NIR scan of a swatch of fabric that is 44% cotton and 56% linen. The right image is a heat-map regression visualization of per-pixel regression estimations from the cotton regression model.

[1]http://www.weardonaterecycle.org/
[2]https://www.cbi.eu/market-information/apparel/recycled-fashion/market-potential)

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