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MATERIAL SORTING USING HYPERSPECTRAL IMAGING FOR BIOCOMPOSITE RECYCLING

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ABSTRACT

The impending exhaustion of non-renewable natural resources emphasizes the importance of sustainable materials. One environmentally friendlier alternative to plastics are biocomposite materials, which are composed of recycled or virgin polymer and a natural fiber material. In order to be to be truly sustainable, the material has to be efficiently recycled, a task which demands a means for their sorting. This paper outlines a method for distinguishing different plastic and biocomposite samples from one another based on hyperspectral imaging. The developed regression model correctly classified 96 % of the samples in the dataset. In the case of biocomposite samples, the accompanying polymer was quite accurately recognized.

INTRODUCTION

Biocomposites are materials composed of natural fibers in a polymer matrix. Since fibrous materials generally have high tensile strengths, they can be used to replace a fraction of the polymer in plastics without losses in load bearing (Kuciel, 2010). If these materials were efficiently recycled, they have the potential to provide a more sustainable alternative to pure plastics. In order to do so, these materials have to be identified and sorted in the waste stream.

Hyperspectral imaging is a technique that constitutes using a light source to illuminate an object and detecting the spectrum of reflected light, which depends upon the chemical composition of the object. This technique has been used to effectively sort different plastics (Vidal 2012) and demolition waste as well (Serranti 2015). However, this method has as of yet not been applied to imaging and recognizing biocomposite materials. According to the authors' knowledge, no methods exist for sorting these materials in waste recycling pipeline.

In order to study the viability of hyperspectral imaging in identifying biocomposites, 152 samples, consisting of 9 different plastics, pulp fibre materials and biocomposites, were imaged using Specim SWIR hyperspectral camera operating in the wavelength range 884 - 2491 nm. The samples were of varying colours, including dark and transparent ones. A model based upon partial least squares (PLS) regression was built for distinguishing materials from one another. Training dataset was generated from pixels containing white and (when possible) transparent samples of all 10 categories (9 different plastic types and the biomaterial).

RESULTS AND CONCLUSIONS

In total, material composition of 96 % of samples were correctly identified. In addition to the aforementioned categories, NC category (not classifiable) was introduced to account for black or dark coloured samples whose material cannot be determined (a common problem in infrared-based sorting). In the dataset, 18 samples were dark or black coloured, and 7 of them *could* be classified according to the plastic, while 11 were categorised as NC. Otherwise, the colour of the samples seemed to have no effect on classification accuracy. The results of the performance of the model is shown in the confusion matrix in Fig. 1.

In the case of biocomposites, 13 of 16 samples were correctly classified according to the accompanying polymer, and 1 sample correctly as NC. The two samples that were misclassified contained only 16 % of pulp fibers, as opposed to the 25 - 50 % in the correctly classified ones. The reflectance signal given by the fiber portion of those samples thus seems to be quite weak. Only one sample was misclassified as biocomposite.

This study establishes as proof-of-concept that biocomposite samples can be classified using hyperspectral imaging. Moreover, since no biocomposite samples were used in the training phase, the model can most likely be further improved by collecting a larger dataset of these samples and using some of them as references in the training set. Future work could also include combining the model with neural networks to see whether classification accuracy can be increased even further.

		Predicted											
		PE	PA	PP	PET	PLA	PS	PVC	PC	ABS	Bio	Composite	NC
	PE	28										1	1
	PA		13										
	PP			18									1
	PET				11								
	PLA					10							1
Actual	PS						12						2
	PVC							13					1
	PC								4				2
	ABS						2			10			2 + 1
	Bio										4		
	Composite	2										13	1

Fig. 1 Confusion matrix of the developed PLS model. In the case of ABS, two samples were correctly classified as NC and one incorrectly (not actually black or dark coloured). Empty cells correspond to 0.

REFERENCES

Kuciel, S, **Kuźniar, P, Liber-Kneć, A. Polymer biocomposites with renewable sources. Archives of Foundry Engineering, 2010, vol. 10, issue 3, p. 53-56.**

Vidal, M, Gowen A, Amigo JM. NIR Hyperspectral Imaging for Plastics Classification. *NIR news*, 2012, vol. 23, no. 1, p. 13-15.

Serranti S, Bonifazi, G. Hyperspectral imaging applied to demolition waste recycling: innovative approach for product quality control. *Journal of Electronic Imaging*, 2015, vol 24, p. 043003-1 - 043003-9.