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MACHINE LEARNING CONCEPTS IN MATERIAL ANALYTICS: CLASSIFICATION OF PLASTIC MATERIALS

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INTRODUCTION AND MOTIVATION

High-throughput classification of plastic types

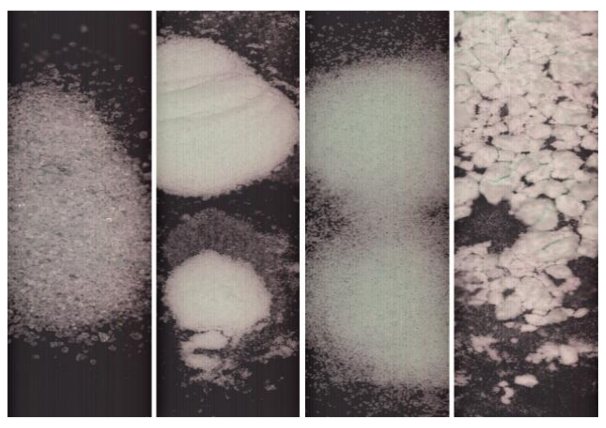
1. **Example: Microplastic** detection and classification: Increasing contamination of water and air requires fast analytic routines
2. **Example: Recycling** of compound materials (e.g. photovoltaic modules): Separation of materials requires separation of materials

Challenge: Automated and universal data analysis approaches for spectral imaging techniques (e.g. Raman spectroscopy, FTIR, hyperspectral imaging)

TEST SAMPLES AND IMAGING METHODS

Typical sample setup:

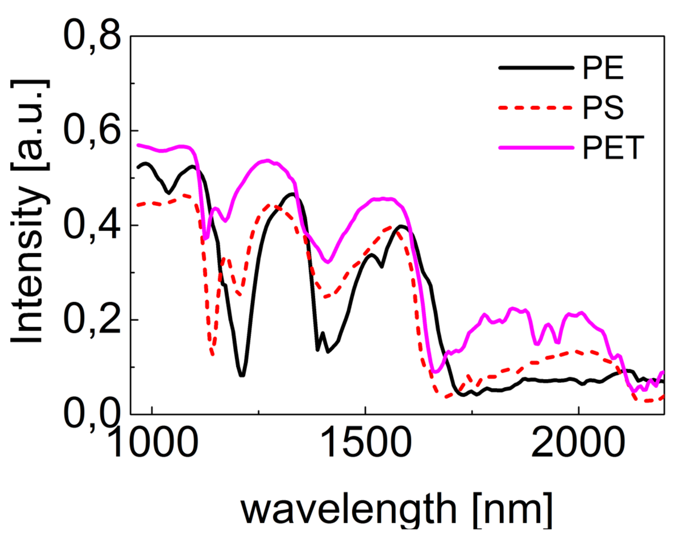
1. Six types of plastics analyzed (PP, PS, PVC, PET, PA, PE)
2. Large samples, powder and micro-particles
3. Environment: air or water



Example: plastic powder

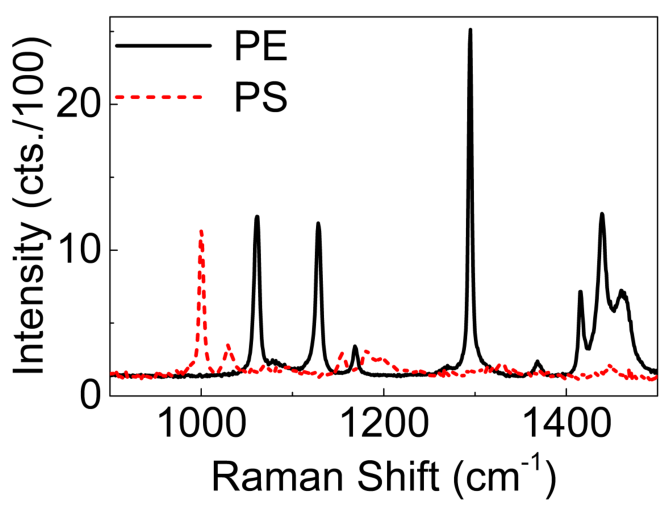
Hyperspectral imaging (HSI):

1. Measurement of spatially resolved reflection spectra in visible and infra-red wavelengths
2. Large data set of high-dimensional data: each pixel with entire spectral information



Raman spectroscopy:

1. Measurement of material properties by inelastic scattering of light
2. Large data set of high-dimensional data: each pixel with entire spectral information



Spectroscopic material analytics:

- Measurements yields **large data sets** (one spectrum for each pixel)
- Efficient, **automated and universal** data **algorithms** required
- **Machine learning approach** and artificial neural nets

ACKNOWLEDGEMENTS

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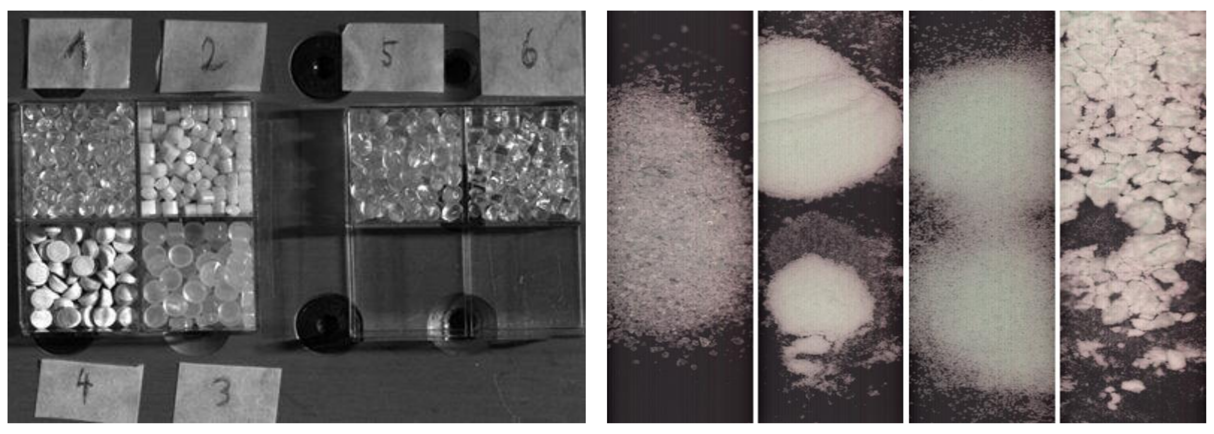
DATA ACQUISITION AND ANALYTICS APPROACH

Plastic particles (1 – 3 mm) | Powder (20 – 150 µm)

Samples



Imaging method

HSI VNIR (400 – 1100 nm) | HSI SWIR (970 – 2500 nm) | Raman

Data analytics

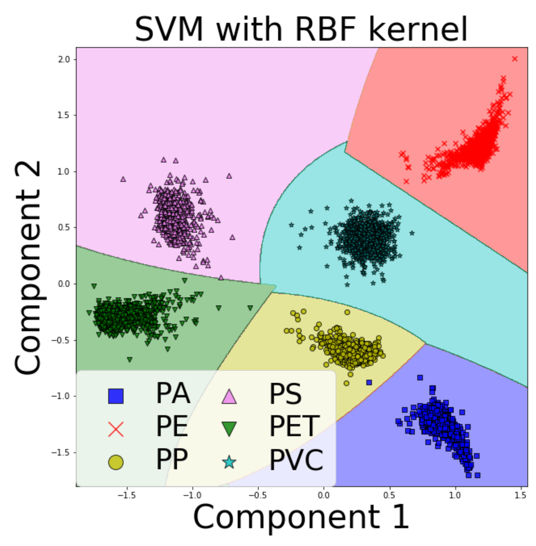
Pre-treatment: Smoothing, normalization, …

Dimensionality reduction

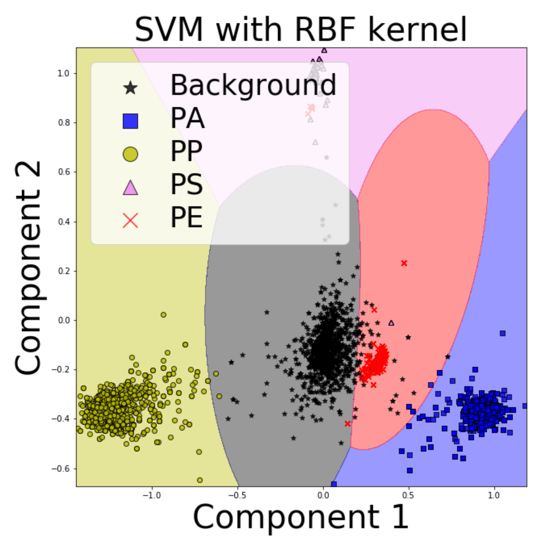
Classification (supervised, unsupervised)

RESULTS: VERY HIGH CLASSIFICATION RATES ACHIEVABLE

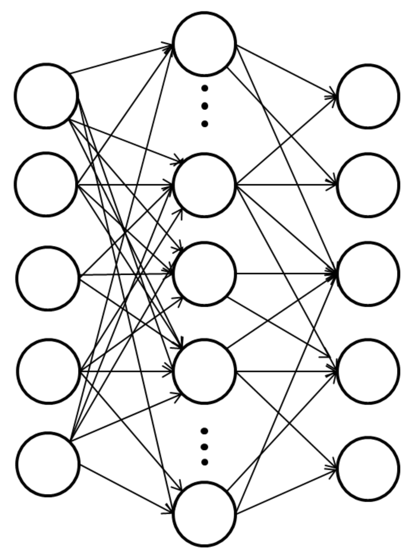
Classification models: Support vector machine | **Artificial neural net**



2dim LDA for HSI



2dim LDA for Raman



ANN structure

		predicted class					
		PA	PE	PP	PS	PET	PVC
actual class	PA	1084	0	1	0	0	0
	PE	0	1032	0	0	0	0
	PP	0	0	1133	0	0	0
	PS	0	0	0	1077	0	0
	PET	0	0	0	0	1008	0
	PVC	0	0	0	0	0	1091

Confusion matrix HIS – SVM

		predicted class					
		PA	PE	PP	PS	PET	PVC
actual class	PA	1085	0	0	0	0	0
	PE	0	1032	0	0	0	0
	PP	0	0	1133	0	0	0
	PS	0	0	0	1077	0	0
	PET	0	0	0	0	1008	0
	PVC	0	2	2	0	0	1087

Confusion matrix HSI – ANN

Machine learning and artificial neural nets:

- Almost perfect classification achievable on test system
- Raman and Hyperspectral imaging as data basis possible
- Both methods reliable (support vector machines or neural nets)