

VNIR and SWIR Hyperspectral imaging for the detection of bacteria on Food-Industry Surfaces

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Hyper Micro Macro Project



Different modalities of Hyperspectral imaging

At different scales

For the detection of bacteria in food related surfaces



Questions



- o Mean or pixel spectra?
- Umbalanced classes:
 - Sampling?
 - Metrics for model evaluation?
- High heterogeneity within classes, very variable differences between classes
 - Discrimination method? Pretreatments?

Jun-Li Xu¹, Ana Herrero-Langreo¹, Sakshi Lamba^{2,3}, Mariateresa Ferone^{1,2}, Anastasia Swanson¹, Vicky Caponigro^{1,3}, Amalia G.M. Scannell^{2,3}, Aoife A. Gowen^{1*} "Exploring the identification of multiple bacteria on stainless steel using multi-scale spectral imaging from microscopic to macroscopic" Scientific Reports (In review)





- Evaluate SWIR and VNIR macroscopic imaging for discrimination dry cells of bacteria on Stainless Steel
- Compare pixel-calibration with mean-spectra calibration for bacteria discrimination



Microbial samples





Sample PreparationCredits : Sakshi Lamba & Mariateresa Ferone



VNIR-SWIR imaging



NEO HySpex Wavelength range: 400-2500 nm

Image integration

Based on four pairs of matching control points







VNIR/SWIR Spectra: Bacteria





VNIR/SWIR Spectra: Replicates



SWIR





PLS-DA with Mean or Pixel spectra?

DRY CELLS 5 BACTERIA



Discrimination modelling



Model Performance Metrics

Accuracy > % CC

Mean Accuracy per Class i : 1/N (Σ CCi)



Dataset Scheme

	Cal	Val	Test	
Апкер	N=100	N=20	N=40	
1	1			
2	2			
3		3		
4	4			
5	5			
6			6	
7	7			
8	8			
9			9	
10	10			
11	11			
12			12	
13	13			
14	14			
15		15		
16			16	

Calibration (100 images)

- Random subset cross validation (100 reps)
 - Select pretreatment & nLV

Validation (20 images)

- Val performance 2020 vs. 2021
- Select wavelength range
- Select model type (PLS-DA or SVM)

Test (40 images)

• Accuracy &

Mean Accuracy per class

Inspect prediction maps

Discrimination results G+/G-PLS-DA VNIR, SWIR, VNIR+SWIR



				Pixel Performance (PLS-D				
		Best Pret.	NLV	Accuracy (%)		Mean Accuracy (%)		
				Val.	Test	Val.	Test	
Pixel Calibr.	VNIR> 406 - 997 nm	SNV	6	90	95	89.6	94.8	
	SWIR> 951 - 2496 nm	SG1	2	70	50	72.9	50	
	406 - 2496 nm	SNV+SG1	5	100	85	100	82.3	
Sample Calibr.	VNIR> 406 - 997 nm	None	1	79.6	77.6	75.2	73.8	
	SWIR> 951 - 2496 nm	None	1	70	74.8	71.1	76.3	
	406 - 2496 nm	None	1	88.7	83.2	87	80	



VNIR/SWIR best model pixel spectra *(test)



406–2496 nm, no pretreatment SVM

GP

GN

VNIR/SWIR best model mean spectra



GP

GN

16



406–997 nm no pretreatment 6LV PLS-DA



PLS-DA with Mean or Pixel spectra?

SIMULATED DATA *(Aoife Gowen)

Accuracy





Mean v's Pixel regression vectors





6 LV PLS-DA model



Conclusions



- Performance of **Pixel-based discrimination models** >>
 Performance of sample-based models
- VNIR range (406-996 nm) >> SWIR Range (951 -2496 nm)
- Combination of VNIR & SWIR ranges improved model robustness, specially for Sample – based models
- Mean based models inherently produced noisier prediction maps (Higher spatial variability)
 - → within sample variability not taken into account in the model
 - \rightarrow sign of overfitting?



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